# FINAL REPORT
# Technical and Economic Analysis of Biomass Storage and Processing Facility

*Prepared for:*
Jefferson County
700 Jefferson County Parkway
Golden, Colorado 80419

*Prepared by:*
McNeil Technologies, Inc.
143 Union Blvd., Suite 900
Lakewood, CO 80228

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## DISCLAIMER



## ABSTRACT

This study is a technical and economic analysis of the feasibility of developing a wood biomass receiving, processing and storage facility in Jefferson County to encourage utilization of biomass from forest fuels reduction on public and private land, urban forestry residues and clean, untreated wood waste from construction activities. Portions of the former Rooney Road landfill and privately owned land adjacent to that site is the primary candidate site of interest, although Jefferson Research Center I located on U.S. 72 in Arvada is also another candidate for development. The primary potential markets for products generated from wood biomass include biomass fuel (in the form of chips and pellets), and potentially ethanol to be used as an automotive fuel additive as cellulose ethanol technologies mature. Annual estimated feedstock availability from forest and other sources ranges from 75,000 to 90,000 tons with much of the variability due to annual forest land treatment by the USFS and other landowners. Increasing a proposed stewardship contract from the USFS from 5,000 to 10,000 acres per year would, conservatively speaking, increase availability to 85,000 to 115,000 tons per year. Estimated capital requirements to design and construct a biomass facility range from $2 to $4 million for facilities that range in production capacity from 60,000 to 260,000 tons per year.

The rationale for involvement of local government includes reduction of risks of wildfire, job creation and development of a biomass supply infrastructure to support alternative fuels industry development. A separate public strategy document, developed in tandem with the technical document, outlines the public benefits associated with biomass utilization and the role that Jefferson County can play in encouraging development of biomass energy markets and deployment of biomass energy technologies.

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Finally, despite our best efforts at editing and revisions, mistakes may still remain within this document. Any mistakes or omissions are the sole responsibility of the authors. Any questions or comments should be addressed to McNeil Technologies Inc., 143 Union Blvd., Suite 900, Lakewood, CO 80228. McNeil staff members who worked on this project are Scott Haase, Tim Rooney, Jack Whittier, Randy Hunsberger and Kristi Moriarty.

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## ABBREVIATIONS AND ACRONYMS

ASTM – American Society for Testing Materials
bdt – Bone Dry Tons, or wood with zero percent moisture content
BFB – Bubbling fluidized bed boiler
bhp – boiler horsepower
BLM – Bureau of Land Management
Btu – British thermal unit
C & D – Construction and demolition
CFB – Circulating fluidized bed
$CO_2$ – Carbon dioxide
CSFS – Colorado State Forest Service
dbh – diameter at breast height
DOE – Department of Energy
EPA – U.S. Environmental Protection Agency
FIADB – U.S. Forest Inventory and Analysis Database
GIS – Geographic information system
GT – Green tons, or wood as received with varying levels of moisture
HFRA – Healthy Forests Restoration Act
HVAC – Heating, ventilation and air conditioning
IFB – Inclined fluidized bed boiler
kW – kilowatt
lb/hr (or lbs/hr) – pounds per hour
MC – Moisture content
MMBtu – Million Btu
MSW – Municipal solid waste
MW – Megawatt
NCAR – National Center for Atmospheric Research
NEPA – National Environmental Policy Act
$NO_x$ – Nitrogen oxides
O&M – Operations and maintenance
ODT – Oven Dry Tons. Wood containing 0% moisture, also referred to as bone dry
PRPA – Platte River Power Authority
PSD – Prevention of Significant Deterioration
PUC – Public Utilities Commission
R&D – Research and development
RD&D — Research, development and deployment
REPI – Renewable Energy Production Incentive
RMNP – Rocky Mountain National Park
RPS – Renewable portfolio standards
RTP – Rapid thermal processing
sf – Square feet
$SO_x$ – Sulfur oxides
USDA – United States Department of Agriculture
USFS – United States Forest Service
UTR – Urban tree residue

# 1 INTRODUCTION

## *1.1 Purpose*

The initial purpose for this project was to assess the feasibility, cost and logistics for Jefferson County to facilitate development of a wood biomass fuel supply infrastructure. The initial driver was the possibility that Xcel Energy could modify its Zuni plant to use biomass as a fuel source. Zuni, which presently uses natural gas, provides steam to the district heating system in downtown Denver and generates electricity during peak periods. Natural gas prices have become increasingly volatile and high in the last several years making the price of biomass more attractive than it has been in the past.

Subsequent to development of the original project scope of work, multiple parties have stepped forth as potential biomass end users. Furthermore, several private parties have emerged as potential leaders to develop wood processing capabilities, with some facilitation by Jefferson County in helping locate and develop an appropriate site. Therefore, the project purpose has evolved to consider the potential that multiple end users could be served and/or the end user could be the operator of a facility on either public or private land. The Jefferson County role has evolved to serve as a facilitator for the project, providing siting and other technical assistance.

This report serves as a resource for potential developers, providing them with planning and technical information about potential sites and the logistics of developing a sustained wood waste supply. The report also outlines roles, responsibilities and economic impacts of a public/private partnership to develop the wood biomass supply infrastructure.

## *1.2 Summary of Activities Performed*

Project activities included evaluating feedstock receiving, handling, processing, storage, and use requirements for: 1) district heating, 2) pellet manufacturing and 3) a pilot scale bioethanol plant. The project team evaluated the potential for the U.S. Forest Service (USFS), other government agencies and urban wood waste resources to meet the demand for these facilities on a reliable basis and at what cost the resources could be obtained. The study focused on two sites identified as having high potential for development in prior studies. In addition, the project team coordinated partnerships between potential end-users, Jefferson County and other stakeholders to generate information about potential options for biomass utilization in the county. The project team evaluated potential business partnering opportunities and ownership structures, identified site infrastructure needs, siting and permitting concerns, estimated site development and capital and operating costs for the facility, developed revenue projections for proposed end-uses and estimated net present value (NPV) and other relevant estimates of financial viability from the perspective of a wood processing facility-owner. Further, estimates are presented on the gross measures of economic development including employment created as well as capital invested.

## *1.3 Description of Study Area and Potential Project Sites*

The project scope covers Jefferson County and the surrounding counties as shown in Figure 1-1. Nearly three million people live in the thirteen counties in the study area.[1]

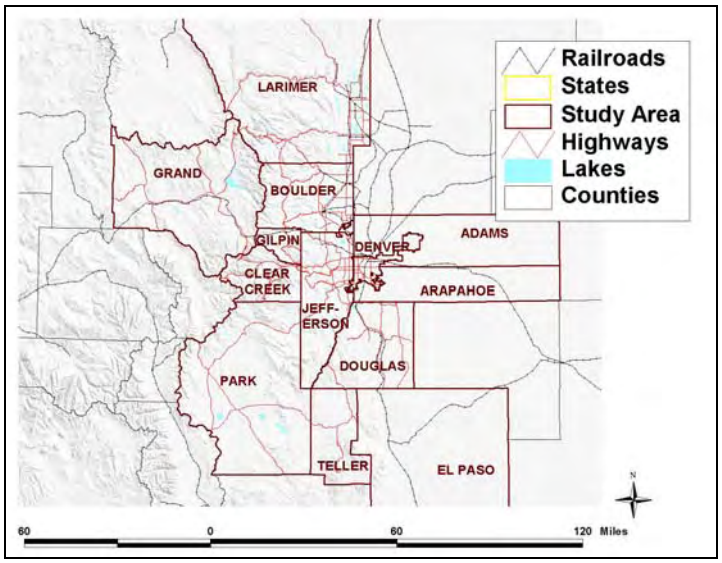


**Figure 1-1. Study Area Map**

Figure 1-2 shows the two sites selected for technical and economic analysis. Each site is described in greater detail in the subsections below.

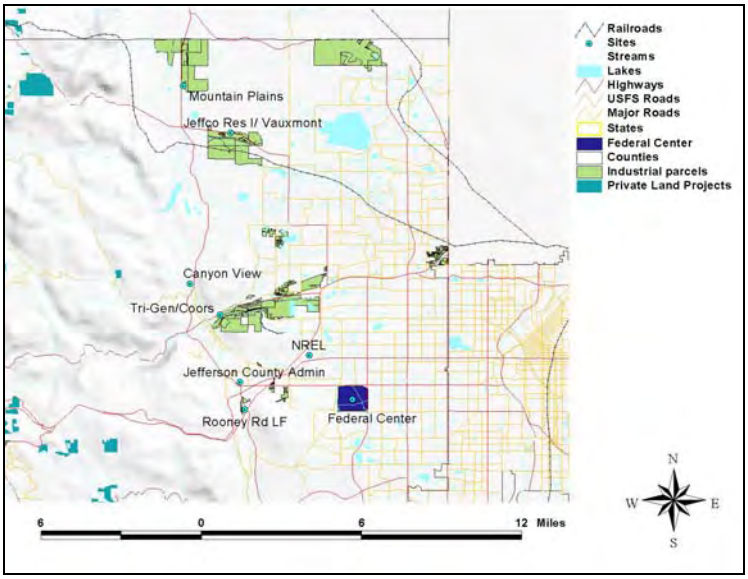


**Figure 1-2. Sites for Analysis as Storage/Processing Areas: Rooney Road Landfill and Jefferson Research Center I**

[1] U. S. Census Bureau, 2000 Census, http://www.census.gov/main/www/cen2000.html.

### 1.3.1 Rooney Road Landfill

The former Rooney Road Landfill, located at West Colfax Avenue and Rooney Road, is a potential location. Figure 1-3 shows an aerial overview of the site and vicinity. At the site there is a landfill gas collection and flare system. This landfill gas is not currently utilized.

**Figure 1-3. Rooney Road Landfill Site and Surrounding Area**

### 1.3.2 Jefferson Research Center I

This 70 acre former industrial site is located adjacent to Highway 72 near the intersection of Highways 72 and 93 north of Golden. The site is zoned industrial and is not easily visible from the surrounding viewshed. Figure 1-4 provides an aerial overview of the location.


**Figure 1-4. Jefferson Research Center I – Aerial Overview**

For more information, contact Howard Lacy, Ralston Development Corporation, 303-422-3545.

# 2 FUEL SUPPLY AVAILABILITY AND COST

This section discusses a variety of fuel supply sources within reasonable hauling distance of the proposed sites.

## *2.1 U.S. Forest Service (USFS)*

**Stewardship contract potential.** The USFS has expressed "90 percent" confidence that it will release a request for proposals in the fall of 2006 for a stewardship contract that would be 10 years in length and treat 5,000 acres per year on the Pike and Arapaho National Forests.[2] This is after a more than two-year long process to evaluate stewardship contracting options following a USFS request for information (RFI) in May 2004 to determine the level of interest in such a contract. One issue cited by the USFS in the length of time it took to consider the stewardship contract option was the absence of an evident end-market for small diameter material. Another issue cited was what to set as the minimum annual cancellation ceiling (dollars) during the life of a long term stewardship contract, as per FAR Subpart 17.1, Multi-year Contracting (Available at http://www.arnet.gov/far) and reasonable bonding requirements.

The stewardship contract would begin with conducting projects that have already gone through the NEPA process, and include more projects as they are scoped out and obtain the necessary NEPA approval. Individual projects with a stewardship contract may take approximately two years to complete. The RFI outlined specifics of project NEPA readiness and the scope of mid-term (through ~ 2010) project planning (Table 2-1). The amount of NEPA approved acreage has increased in the meantime. Budget limitations have in the past and likely would limit the desired range of annual treatment in the future to annual acreages below those in Table 2-1.

**Table 2-1. Range of Annual Treatment for Pike and Arapaho-Roosevelt National Forests**

| Area | NEPA-approved mechanical treatment (acres) | Desired range of annual treatment (acres) | Decision notices | Future planning areas (acres) |
|---|---|---|---|---|
| Pike NF | 35,000 | 2,500 – 4,000 | www.fs.fed.us/r2/psicc | 17,000 |
| Arapaho and Roosevelt NF | 16,000 | 2,000 – 6,000 | www.fs.fed.us/r2/arnf/projects/ea-projects/index.shtml | 29,000 (by 2009) |

The predominant species harvested will include ponderosa pine and mixed conifer. Most trees will be less than 7 inches diameter at breast height (dbh). Forest stands include anywhere from 100 to 2,000 stems per acre. Probable volume yields would range from approximately 200 to 500 cubic feet per acre with 90 percent of that volume in the 5 to 7 inch dbh range. Approximately 10 percent may be larger in size. Converting this to weight assuming 40 lb per cubic foot of wood, yields would be expected to be four to ten GT per acre.[3] Published yields have been higher.

[2] Bob Garcia, USFS Region 2, personal communication with Tim Rooney, May 31, 2006.

[3] USFS Wood Handbook published values provide densities of 41 and 40 lb per cubic foot respectively for ponderosa pine and mixed conifer at typical wood moisture contents and specific gravity.

There was no explicit requirement to remove biomass from the site in the RFI. Slash guidelines were created to be flexible to permit piling and/or mastication as treatment options if they are more appropriate for the site. Slash guidelines could remain an issue for biomass availability, as mastication treatments in particular can be significantly less expensive on a per acre basis than biomass removal. The aesthetic and other issues associated with mastication treatment are a matter of debate. Mastication effectiveness, when compared with thinning and biomass removal and/or prescribed burning, should be considered when evaluating the range of treatments to be considered as part of the stewardship contract.

Assuming mechanical treatments of 5,000 acres per year, the overall product yield would be 20,000 to as much as 50,000 GT per year. However, it is unclear whether biomass material would be removed from all 5,000 acres per year due to site specific conditions and uncertainty related to treatment methods. To be conservative, it would be best to assume that this is not the case for at least 50 percent of the acres treated. This factor can be revised as more project experience is obtained. Our conservative assumptions have the result of decreasing projected biomass availability to as little as 10,000 to 25,000 GT per year for the stewardship contract, unless yields increase and/or the USFS commits to biomass availability from a minimum number of acres. Total projected usage by the scenarios evaluated was 230,000 GT per year for a district heating and power generation application (~45,000 for heating and the remainder for peak power generation), 65,000 tons per year for a pellet plant and approximately 120,000 tons per year for a proposed ethanol plant.

Therefore, the stewardship contract alone (without other USFS projects) would likely be inadequate to supply 50 percent of the facility needs reliably for any of the facilities considered, unless one or more of the following occur:

- Per acre yields are higher (which will likely be the case, since the yields in the RFI do not include material less than 5 inches in diameter and assumed yields are conservative) ;
- Mechanical treatment acreages increase (reducing variability in annual overall biomass availability due to differences in the mix of treatments and projects implemented on the ground) ; and/or
- Guarantee biomass availability in terms of a tons per year and/or acres per year

Other alternatives include evaluating the potential to use wood only for heating rather than heat and power generation at the proposed district cogeneration application and scaling the pellet plant to match the available resource. The biomass ethanol facility scaleup will probably not occur for several years, allowing a gradual buildup of biomass demand as the supply infrastructure develops.

However, we recommend that at a minimum the stewardship contract should include targets for completing a certain amount of mechanical treatment each year, require biomass removal to the extent possible and set a minimum floor for the biomass product yield to be provided from projects in a given year.

Quantitative projections of fuel supply availability by month would be speculative at best, although intermittent limitations on availability can be expected in January through early spring for climatic purposes and at other times due to site-specific restrictions such as wildlife and conflicting uses. Accumulation of biomass from forest sources will therefore likely occur in the

summer through early winter, with corresponding increased demands on the process facility in that period.

Proposals for performance based service contracts would be rated on a variety of factors, including past performance, experience, Experience (what you've done), product removal: utilization and merchandizing (sawtimber, biomass, products other than logs), price (cost to government) and minimizing adverse environmental effects and impacts (treatment and transportation). Forest stewardship contracting guidelines provide some leeway for consideration of local participation such as the role Jefferson County could play in this process in the selection of awardees. Local, regional and probably national approval would be required for a less-than-competitive bid process however.

**Potential for biomass subsidy from USFS.** USFS cannot verify its ability to subsidize transportation costs for materials generated as a result of fuels reduction. There have been proposed fuel subsidies and/or tax credits of up to $20 per ton in a variety of pieces of natural resources legislation but the only policy incentive to date includes a grant provided for by 2005 Energy Policy Act legislation. There have not been Congressional appropriations of funds and the mechanism for availability of that money is not clear.

**Comparison of Stewardship Contract with Past and Planned Treatment Actions.** Past performance by the USFS indicated that within an approximate 80-mile radius of Jefferson County, annual biomass availability averaged approximately 65,000 to 140,000 GT per year for the Pike & San Isabel and Arapaho & Roosevelt National Forests. This assumed 50 percent availability of the biomass generated from treatments on the ground from 2002 to 2005 and a 10 ton per acre yield. The estimate of biomass availability based on past (from 2002 to 2005) projects was based on an exhaustive search of projects originally presented in the precursor study to this effort. Project data were provided by GIS specialists and forest silviculturalists at the Arapaho & Roosevelt National Forest[4] and the Pike & San Isabel National Forests.[5] Additional project treatment information was provided by the USFS Rocky Mountain Region Accelerated Watershed/Vegetation Management Program strategic plans.[6]

Estimated availability of biomass from ongoing and future projects averages approximately 95,000 GT per year from 2006 through 2008 and there is little variation in annual generation (Table 2-2). This estimate assumes a biomass yield of 10 GT per acre, 50 percent availability of forest biomass from projects and average annual combined treatment of 18,920 acres per year for the Arapaho-Roosevelt and Pike-San Isabel National Forests combined. Data for planned projects from 2006 through 2008 were compiled from the USFS Rocky Mountain Region

[4] Brian Banks, GIS Analyst, USFS Pike & San Isabel National Forests, South Platte Ranger District, (303)275-5638 bbanks@fs.fed.us; Fred Patten, Large Scale Watershed Planning, USFS Pike & San Isabel National Forests, (303) 275-5641, fpatten@fs.fed.us.

[5] Kevin Zimlinghaus, South Zone Fire Team Planning Silviculturist, USFS Arapaho & Roosevelt National Forests Boulder Ranger District, (303)245-6415, kzimlinghaus@fs.fed.us; Janice Naylor, GIS Coordinator, Arapaho & Roosevelt National Forests, Canyon Lakes Ranger District, (970)494-2723, jnaylor@fs.fed.us ; Steve Johnson, Silviculture Forester, Arapaho & Roosevelt National Forests, (970)498-1374, sjohnson04@fs.fed.us.

[6] USFS Rocky Mountain Region, Accelerated Watershed/Vegetation Management Program, http://www.fs.fed.us/r2/fire2/nfp/awrpstrategy/

Accelerated Watershed/Vegetation Management Program strategic plans and additional NEPA information gathered from public notices for planned projects.

**Table 2-2. Summary of Planned Treatment Acreage and Biomass Availability by USFS Unit and County, 2006 – 2008**

| Treatment year | County | Treatment acreage - ARNF | Treatment acreage - (PSICC) | Treatment acreage - total | Availability - (GT/year) | Average haul distance (miles) |
|---|---|---|---|---|---|---|
| 2006 | Boulder | 2,100 | - | 2,100 | 10,500 | 35 |
| | Douglas | - | 4,450 | 4,450 | 22,252 | 37 |
| | Grand | 2,000 | - | 2,000 | 10,000 | 56 |
| | Jefferson | 500 | 1,000 | 1,500 | 7,500 | 30 |
| | Larimer | 4,470 | - | 4,470 | 22,350 | 90 |
| | Park | - | 4,200 | 4,200 | 21,000 | 110 |
| | Teller | 150 | 1,500 | 1,650 | 8,250 | 119 |
| | UNK | 141 | - | 141 | 705 | 75 |
| 2006 Total | | 9,361 | 11,150 | 20,511 | 102,557 | 78 |
| 2007 | Boulder | 1,700 | - | 1,700 | 8,500 | 35 |
| | Douglas | - | 3,000 | 3,000 | 15,000 | 44 |
| | Gilpin | 1,000 | - | 1,000 | 5,000 | 62 |
| | Grand | 900 | - | 900 | 4,500 | 93 |
| | Jefferson | - | 1,000 | 1,000 | 5,000 | 42 |
| | Larimer | 4,550 | - | 4,550 | 22,750 | 92 |
| | Park | - | 3,200 | 3,200 | 16,000 | 73 |
| | Teller | - | 2,000 | 2,000 | 10,000 | 119 |
| | UNK | 1,000 | - | 1,000 | 5,000 | 75 |
| 2007 Total | | 9,150 | 9,200 | 18,350 | 91,750 | 74 |
| 2008 | Boulder | 1,400 | - | 1,400 | 7,000 | 37 |
| | Douglas | - | 3,000 | 3,000 | 15,000 | 44 |
| | Gilpin | 2,000 | - | 2,000 | 10,000 | 62 |
| | Grand | 200 | - | 200 | 1,000 | 66 |
| | Larimer | 6,000 | - | 6,000 | 30,000 | 94 |
| | Park | - | 2,100 | 2,100 | 10,500 | 37 |
| | Teller | - | 2,000 | 2,000 | 10,000 | 119 |
| | UNK | 1,200 | - | 1,200 | 6,000 | 75 |
| 2008 Total | | 10,800 | 7,100 | 17,900 | 89,500 | 75 |
| Average | | 9,770 | 9,150 | 18,920 | 94,602 | 75 |

There are significant discrepancies between both the estimates of past treatment and planned treatment (based on the Accelerated Watershed/Vegetation Management Plan prepared by district forestry staff) and desired treatment acreage indicated by the RFI released by the USFS Region 2 (see Table 2-1) and the size of the proposed stewardship contract offering. Estimates of biomass from past treatment showed annual treatment acreage ranging from a low of 1,650 in 2002 to a high of over 28,000 acres in 2004, for an average of more than 15,000 acres treated during that period. The planned projects for 2006 through 2008 show average annual treatment of more than 18,000 acres per year. However, as shown in Table 2-1, desired annual treatment for the ARNF and PSICC combined ranges from only 4,500 to 10,000 acres per year, slightly more than half of what planning data suggest are ready for 2006 through 2008. If treatment approaches 10,000 acres per year, then at yields of 10 tons per acre and 50% availability of forest biomass, 50,000 tons of biomass could be available from the USFS each year. This is slightly

more than half of what we would expect if annual treatment goals in accelerated watershed/vegetation and NEPA planning documents were accomplished. The proposed stewardship contract would treat only 5,000 acres per year.

The discrepancies between planned projects and annual "desired" treatment goals seem to indicate that USFS foresters at the Ranger District level have more aggressive treatment objectives than can be supported by current treatment budgets available at the National Forest and Regional levels. Availability of biomass quantities in more aggressive vegetation plans is contingent on treatment budgets for USFS and the adequacy of staffing levels on the Ranger District and National Forest levels to do the surveying, engineering and other work necessary to prepare projects for sale. This is only one reason to evaluate the potential for consolidating projects within a geographic area to reduce both administrative and treatment costs.

The stewardship project scope should be increased to cover additional projects both for purposes of biomass utilization but also to create a geographically meaningful area to track performance and effectiveness of the stewardship contracting mechanism. At the very least, mechanical treatment levels of at least 10,000 acres each year, the high end of the "desired" treatment levels would facilitate biomass market development in the area. This could require additional federal budget appropriations for fuels treatment but also for additional staffing at the district, National Forest and regional levels.

## *2.2 Colorado State Forest Service (CSFS) and Other State Agencies*

The Colorado State Forest Service and other state agencies, such as the Colorado Governor's Office of Energy Management and Conservation (OEMC) can play roles in coordinating fuel supplies from private landowners and serve as a repository for presenting supply and demand information across multiple biomass user groups as the biomass industry matures in Colorado.

## *2.3 Urban Resources*

Several companies working in the wood industry were contacted to determine the quantity and disposal methods of waste woods. Company types include tree care firms, landfills, construction, pallet, truss, and wood recyclers. Large construction companies use turn-key frames with very little wood wastes generated on the construction site. These companies contract with waste companies and do not actually own their wood or other wastes. Small contractors building between 5-15 homes annually tend to rent one dumpster where all wastes are deposited and later collected by a waste management company. Wood wastes could not be quantified from homebuilding and wood recyclers who obtain construction debris were contacted instead.

### *2.3.1 Pallet Companies*

There are 14 pallet companies in the Front Range. All were contacted and interviews were conducted with eight. Wastes are typically clean, broken pallets containing nails. Some companies deliver their wastes to wood recyclers while others have their wastes collected by recyclers. The company with the lowest volume of wastes pays to dispose. All other companies either dispose of wastes woods for free or sell them. Ifco Systems of Commerce City is the largest pallet company generating 600 yards$^3$/week and all wastes are sold to A-1 Organics under contract. Two companies are willing to deliver wood wastes to Golden, however, neither of these companies could provide volume data. Other pallet companies interviewed were undecided on

delivery. Most companies haul their wastes to wood recyclers and are able to deposit at no cost. Table 2-3 summarizes volume data from pallet companies.

**Table 2-3. Pallet companies reporting wood waste volumes**

| Company | Annual Wood Waste Volume | |
|---|---|---|
| | Cubic yards | Tons |
| Denver Reel & Pallet Company | 2,080 | 416 |
| E & R Pallet Repair | 3,774 | 755 |
| Frisco Pallet Service | 4,160 | 832 |
| FJ Pallet Service | 624 | 125 |
| C&C Pallet Remanufacturing | 4,264 | 853 |
| Ifco Systems | 31,200 | 6,240 |
| Total | 46,102 | 9,220 |

### *2.3.2 Tree Care Firms*

There are approximately 129 tree care firms reasonably close to Golden. All of the companies were contacted in Arvada, Aurora, Bailey, Boulder, Broomfield, Centennial, Commerce City, Conifer, Denver, Englewood, Evergreen, Golden, Lakewood, Littleton, Morrison, Thornton, Westminster and Wheat Ridge. Telephone interviews were conducted with 71 of the companies of which 55 reported volumes. Swingle, believed to be the largest tree care firm in the Front Range, has not provided volume data. Table 2-4 summarizes volume data provided by tree care firms. Table 2-5 classifies the number of companies by the amount of waste they generate. Most companies generate less than 3,000 cubic yards of material (approximately 600 tons) per year.

**Table 2-4- Tree care wood waste volumes**

| Company | Annual wood waste volume | |
|---|---|---|
| | Cubic yards | Tons |
| Based on 55 companies interviewed | 177,892 | 35,578 |

Note: 46 companies reported generating 150,277 cubic yards of material; Nine reported generating 5,523 tons. Units made consistent assuming 5 cubic yards per ton.

**Table 2-5- Tree care waste volume categories**

| Wood Waste Volume ($yd^3$) | # of Companies |
|---|---|
| <500 | 9 |
| 500-1000 | 9 |
| 1000-3000 | 15 |
| 3000-6000 | 7 |
| 10,000-20,000 | 3 |
| >20,000 | 2 |

Nearly all interviewed tree care companies own a chipper and chip the majority of their wood wastes. Disposal methods vary with most companies giving away chips to customers and nurseries with the remainder delivered to wood recyclers. The primary wood recyclers are Oxford Recycling, Mountain States and A1 Organics. Both Oxford Recycling and Mountain States are located in Englewood by the intersection of Santa Fe & 285. A1 has drop off locations in northern Golden and Stapleton. Interviewees indicated that the price for drop off was high for

Oxford Recycling and Mountain States. Wood wastes in log form are generally split and either sold or given away as firewood with the exception of cottonwood which must be delivered to wood recyclers. Only two small companies routinely take wood wastes to landfills.

Nearly all tree care companies are interested in additional drop off sites to dispose of their wood waste provided there is no fee or it is minimal. Delivery of wood wastes is dependent on location. Companies located in or near Jefferson County are open to delivering their wood wastes to Golden whereas companies at greater distances are less likely to incur fuel and labor costs to deliver chips and logs to distant drop off sites.

Some companies are not interested in this project as they already have relationships with firewood companies or other individuals that enable them to dispose of all of their waste wood for free or in some cases for profit. Nine companies indicated that they would not be interested in delivering wood wastes to Jefferson County or other drop off centers. Four of these companies reported volume data of 8,306 cubic yards.

The following summarizes data for the largest tree care companies:

Davey Denver
- Approximately 14,000 cubic yards per year—mostly chips
- Deliver wastes to A1-drop off at no charge and the rest goes to nurseries
- They do not pay to dispose of any wood

Davey Boulder
- Generate 13,000 cubic yards per year—slightly more chips than logs
- 14,000 cubic yards of chips are currently onsite
- Yard is located in NE Boulder near Xcel power plant
- they are interested in serving as a drop off location for an energy project

Hayes Boulder
- Highest generation in front range
- 21,900 cubic yards/year (60% chips, 40% logs and brush)
- 5,000 cubic yards chips and 4,000 cubic yards logs on site
- Not interested in delivery but would provide wood if it was collected

Discount Tree Service Aurora
- 20,800 cubic yards-20% chips, 80% logs/brush
- Above estimate is conservative based on average winter work—in summer may be 3x more
- Give away 50%; 50% to Oxford recycling
- Interested in free or inexpensive drop off center but location dependent

Rocky Mountain Tree Service Arvada
- 2,190 tons/year-vast majority are chips
- Gives away 30%, 70% goes to recyclers (A1, Oxford, etc.)
- Interested in delivering wood wastes to a Golden location

### *2.3.3 Wood Recyclers*

There are several large wood recyclers in the Front Range collecting wood wastes from pallet, tree care, construction and other wood product companies. Meetings were conducted with Colorado Waste Services and Western Disposal to discuss possibilities of purchasing their waste woods. Colorado Waste Services (CWS) has a considerable amount of wood waste on site which is processed into tree healer, mulch and finger joints. A summary of wood residues collected by recyclers is in Table 2-6.

**Table 2-6-Recyclers wood collection volumes**

| Company | Annual Wood Waste | |
|---|---|---|
| | Cubic yards | Tons |
| A1 Organics | 500,000 | 100,000 |
| Colorado Waste Services | 60,000 | 12,000 |
| Oxford Recycling | 150,000 | 30,000 |
| Western Disposal | 25,000 | 5,000 |
| Total | 735,000 | 147,000 |

Colorado Waste Services (CWS) located in Denver (54$^{th}$ and Washington) collects roughly 25% of large home builder construction wastes in the front range. Transfer sites at their headquarters and Stapleton charge $2-5/cubic yard depending on quality. CWS processes 55,000-60,000 yards$^3$ of wood waste into usable products annually. The highest quality wood is used to manufacture finger joints. They sell about 45,000 yards$^3$ of Ecomulch annually which is made from pallets, two by fours and similar wastes. Tree healer is made from yard and treated wood wastes such as OSB and plywood in amounts of approximately 15,000 yards$^3$. Wood collection can be increased if a market is known.

Western Disposal is located in Boulder and collects a significant amount of country trash and other wastes. They operate the Boulder County wood waste drop off facility which collects between 200-300 cubic yards daily. They estimate that 50% of their wood wastes are collected by Boss Compost and the remaining half is processed into colored mulch onsite for wholesale and retail sales. Wood collection can be increased if there is a known market. Western Disposal estimates that 25-30% of 15,000 tons of trash collected monthly is wood waste. Mulch and other wood products have undergone proximate and ultimate analysis conducted by Soil Control Laboratory.

A-1 Organics collects 500,000 yards$^3$ annually of wood wastes. Several tree care companies mentioned that drop off rates are lower at A-1 than Oxford Recycling or Mountain States. Davey, a large tree care firm in Denver, has an agreement where all wood wastes can be delivered free to A-1's Lost Antlers Facility north of Golden. A-1 Organics uses wood and other organic wastes to make compost and mulch and sells all of its products. Tom Lincoln, A-1 Production Manager, believes a biomass plant would be in competition with wood recyclers.

Oxford Recycling is the most common drop off point mentioned during tree care firm interviews. They collect roughly 150,000 yards each year and process wood wastes into mulch and other similar products. They do not have excess wood and are not interested in supplying wood for an energy project. Mountain States also is not interested in supplying wood and did not provide volume data. Organic Supply, owned by Morning Fresh Farms in Platteville, declined to provide volume data and believes there is a shortage of wood wastes in the Front Range.

### *2.3.4 Summary of Urban Resource Availability*

The estimate of clean wood waste availability from wood recyclers is based on several assumptions. First, it assumes that 60,000 cubic yards (12,000 tons at 5 yards per ton) of material sold by CWS as mulch could be diverted to a facility at an economically competitive price. Next, it assumes that 30 percent of recoverable wood waste from Western Disposal is used for biomass energy. An estimated 25 percent of 180,000 tons of total material received each year at Western Disposal is wood, or 45,000 total tons of wood. Of this, we estimate that 30 percent, or 13,500 tons, of wood is recoverable clean wood waste. Table 2-7 summarizes wood waste availability from urban resources at 65,000 tons per year. This is a conservative estimate because it does not count potential growth in recycling that could be observed if a known market develops for the urban wood waste material, especially if that material can be obtained through existing suppliers such as A-1 Organics, Western Disposal and CWS.

**Table 2-7. Summary of Urban Waste Wood Availability**

| Type | Potential availability (tons/year) |
|---|---|
| Pallets (50% of total disposal) | 4,500 |
| Tree care | 35,000 |
| Wood recyclers | 25,500 |
| Total | 65,000 |

This summary is a conservative estimate as well because it focuses on producers within Jefferson and Denver Counties. Increasing the scope could dramatically increase availability.

## *2.4 Resource Summary*

Total biomass availability from the USFS proposed stewardship contract and urban resources is an estimated 75,000 to 90,000 tons per year, with variability associated with yields from forest thinning projects. This is a conservative estimate. Including estimated annual availability from USFS sources based on a stewardship contract for 10,000 acres per year increases this availability to 85,000 to 115,000 tons per year, suggesting that an increase in the scope of the proposed stewardship contract could be a viable goal to pursue. This resource base is adequate to support a pellet mill and heating only for the portion of the Denver district heating system served by the Zuni plant, but too small to support both heat and power generation for a district heating application or a proposed ethanol facility. Increasing the geographic scope of the supply area could change this assessment of the adequacy of the resource for the latter applications.

# 3 BIOMASS FUEL SUPPLY LOGISTICS

This section provides an overview of a biomass supply system; fuel specifications; delivery schedules; fuel receiving, handling, processing, storage and transfer requirements for offsite processing and storage facilities and fuel contracts for a wood fired district heating system.

The following subsections describe an overview of biomass supply systems, general storage/processing system components, fuel quantity requirements, fuel specifications, delivery schedules and fuel processing and storage infrastructure requirements needed to supply 1) a large industrial district heating facility (Xcel Energy Zuni Plant used as model) 2) a pellet manufacturer and 3) a pilot-scale biomass ethanol facility. Section 2 discusses fuel supply sources and reliability in more detail.

## *3.1 Overview of Biomass Supply System*

The key components of the supply system include generators of urban and forest biomass. Urban biomass suppliers include wood recycling companies, waste disposal companies, arborists and landscapers. Forest biomass suppliers include private landowners, government agencies and the contractors that manage their land. Figure 3-1 provides a general overview of the biomass supply. The biomass supply system must be designed to continue to operate even if one component of the system breaks down. Therefore, maintaining an adequate network of suppliers to buffer impacts on the biomass supply due to changes in housing markets that affect construction residue availability, fluctuations in annual work by arborists and landscaping companies and fuels reduction and other forestry projects.

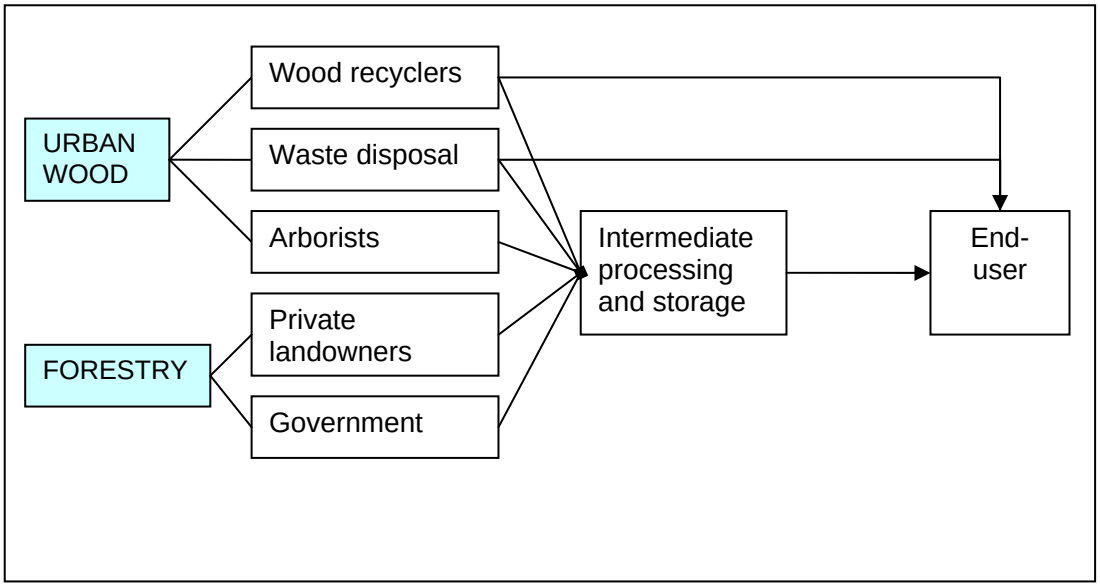


**Figure 3-1. General overview of biomass supply network**

In addition, fuel receiving, processing, storage and fuel reclaim systems will need to have contingency plans to permit operation in the event that any system component fails.

## *3.2 Fuel Receiving, Handling, Processing and Storage Systems*

This section provides an overview of the fuel supply system from the point where it enters the gate of a fuel processing and storage facility to delivery to the end-user. It also presents information on the special requirements for short-term fuel storage at an off-site industrial district heating system with on-site space constraints.

The storage facility would receive, sort, process and store wood biomass fuel for a fee from generators, or for some generators for a small purchase price. The following subsections discuss material receiving, handling, processing and storage options for both components of the system.

### *3.2.1 Fuel Receiving, Handling, Processing and Storage System Overview*

This section discusses wood fuel receiving and handling, storage and fuel chip reclaim systems for the fuel processing and storage location. Contingencies need to be planned to ensure that the fuel supply will continue to be reliable even if a component of the fuel storage and handling system fails. This section discusses the need for redundant systems to avoid supply interruptions.

**Wood Fuel Receiving and Handling.**

Typical components of a wood fuel receiving and handling system include an access gate, security booth, truck dump and/or live bottom pits, conveyor system with magnet and non-ferrous metal detector, grinder and screens, conveyor to storage area, storage pile and/or silo and wood chip fuel reclamation system. A variety of system configurations are possible. This section provides an overview of typical components of existing applications in this size range.

Access control to the site is typically by security gate and booth (see Figure 3-2). From the access point the receiving procedure for deliveries frequently consists of the following steps:

- Truck receiving and check-in
- Move to truck inspection/scales
- Visual inspection of load
- Possible sampling of truck contents for moisture and/or chemical composition of fuel
- Truck weighing
- Assignment of unloading point
- Unload at truck dump or live bottom bin
- Return to truck scales for weighing

The visual inspection, truck sampling and weighing can occur at the same time.

**Figure 3-2. Truck Receiving and Security Booth in Reno, Nevada**

The choice of whether to use truck dumps and open or partially enclosed storage, live bottom pits, or combination of both depends on space availability/site layout, volume of throughput required, economics and a need for flexibility to accommodate different supplier truck types. Unloading time varies by technology and a host of site-specific factors. Truck trailer dump systems generally take approximately three to five minutes to unload, vs. 12 to 15 minutes for a live-bottom system.[7] Load inspection, sampling and weighing can add approximately three to five minutes of time per load for both truck dump and live bottom systems. Capital costs and space requirements for a truck dump can be higher than for a live bottom system. A hydraulic truck dump with live-bottom receiving hopper costs approximately $300,000 installed.[8] Open pile storage or a combination of open pile storage and a partially enclosed shed is less expensive, but provides less control over fugitive dust emissions and pile moisture content. Accepting material from a live bottom trailer would require a receiving hopper or bin. Unloading construction waste will require a separate pile storage area.

Required truck unloading capacity depends heavily on daily truck arrivals and the timing of supply availability during the year. Because trucks often show up at unloading sites at random times, one design criterion is to specify a system to accept 1/3 of the daily wood fuel load in ½ of the day, to account for surges in truck receiving.[9] For this application, a majority of the waste wood received is likely to be received from May through November, as construction, forestry and urban forestry activities are concentrated in these months. A first-in first-out inventory system should be employed so that the overwhelming chip pile is not stored longer than six months. Pallet and construction residue can be unloaded onto concrete or asphalt pads in separate piles with fewer concerns related to dust or other emissions.

The next steps in the supply chain are to:

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[7] Joseph Lynn Tilton, "Transfer Trailers: Keep the Wastestreams from Flooding Communities", *MSW Management*, January/February 2001, http://www.mswmanagement.com/msw_0101_transfer.html

[8] Phillip C. Badger, Processing Cost Analysis for Biomass Feedstocks, prepared for Oak Ridge National Laboratory, Oak Ridge, TN, ORNL/TM-2002/199, October 2002, 17.

[9] Phillip C. Badger, October 2002.

- convey chipped or ground material to be screened and further processed as needed,
- grind unground material such as pallet and clean construction waste, and
- convey material to storage pit or pile to be screened and further processed as needed.

Pallet and clean construction waste can be ground then unloaded into pit or pile via conveyor or truck. Front end loaders and grapple boom loaders can be used to load material into the tub grinder. Ground, shredded or chipped material is often fed from feedstock bins using a live bottom system to a conveyor, past a magnet system to remove ferrous materials and sometimes a non-ferrous metal system to detect other metallic debris and stop the conveyor to avoid damaging grinding equipment. A trommel screen may be used to remove stones or other debris but this is not common. Material from the conveyor is then fed past a screen. An oscillating disk screen that can handle material from 1 to 6 inches (25 to 150 mm) in diameter is commonly used.[10] Correctly sized materials fall onto a conveyor to go to the storage area. Oversize material is fed to size reduction equipment.

The type of size reduction equipment depends on the moisture content and other characteristics of the material. Common size reduction equipment includes chippers, hammermills, tub grinders and wood hogs. Chippers use a series of knives that rotate at high speeds to reduce fuel sizes, and can handle moisture of any moisture content. Metal and foreign matter can damage chipper blades, increasing maintenance requirements. A hammermill uses high speed rotating hammers that smash or crush material against an anvil. They are typically used to produce particles that range from 1 to 9 inches in diameter. Many require moisture content of less than 15 to 20 percent, and larger materials such as slabs and trim ends may need to be ground or chipped before entering the hammermill. Tub or hopper grinders are capable of handling a wide variety of material but can produce longer, stringy materials that can be difficult to handle and can cause problems with fuel infeed systems. This can be overcome by using tub grinders to do the primary processing then passing the material through a chipper. A variety of types of equipment is referred to as wood hogs, including horizontal end-feed shredders or grinders and strip shredders. Wood hogs shred or grind material, often using hammers, knives mounted on a rotor, rotary discs combined with swinging hammers, or disks mounted with teeth that grind material. Some "hybridized" wood hogs are capable of producing higher quality material than grinders. Wood hogs are capable of handling a wide variety of feedstocks and are often more tolerant of moisture content variation and foreign material than other size reduction equipment.

## Wood Fuel Storage Options

The four primary options for storage over a period of several months include open pile storage, an open-sided storage shed, bunker, or concrete or metal silo storage. These options are listed in order of increasing cost. The advantages to pile storage include simplicity and low cost. A belt conveyor or drag chain conveyor can be used to stack fuel in an open pile or partially enclosed pile. Disadvantages to open piles include greater area required and less control of fugitive dust emissions and moisture content. More expensive but providing more functions, a radial boom stacker can be used to stack, move and load open piles. An open-sided storage, covered bunker or silo provides greater control of fuel moisture content and dust emissions than open pile storage alone. This is a consideration in and near Jefferson County where high winds could create a dust nuisance and/or fire hazard. A buried, covered bunker allows trucks to dump

[10] Phillip C. Badger, October 2002.

directly into it and can be equipped with a live bottom to remove fuel. Silo storage offers the advantage of greater control of dust and fuel quality, drive-through truck loading and smaller area requirements. Cost, complexity and height are the major disadvantages of silo storage. Wet fuels can also freeze in silos, necessitating chain flails or augers to prevent fuel blockages.

Using a concrete pad for the floor of storage areas reduces the opportunity for rock or debris to be reintroduced but having a large concrete pad storage area can be cost prohibitive. Large storage areas often use a levelled earth pad with a crushed rock base or variation thereof. Asphalt surfaces are gouged by front-end loaders and are thus not typically used. Pile heights up to 50 feet are not uncommon, although pile height can be limited due to restrictions on wind-blown debris and the need to manage pile moisture content to prevent pile overheating.

Moisture content and the risk of spontaneous combustion are a risk both with piles but also with silos, but it is likely that air movement would be lower for silo storage. Pile turning can help reduce the risks of pile fires. Moisture range between 20 and 45 percent is critical for generating enough biological activity in a pile or silo to generate heat and increase the risk of spontaneous combustion. Below 20 percent not enough moisture is present, and above 45 percent enough moisture is present to allow evaporation to keep piles cool.[11] Therefore for long-term storage (i.e., longer than 20 days) it is recommended to store dry chips or alternatively to turn piles at least once every 20 days to avoid temperature build-up and attempt to maintain an even moisture content distribution within the pile. Use of a dryer would eliminate the need for pile turning, create a higher quality fuel and dried covered chips could be stored for up to six months.[12] Pile temperature monitoring should be conducted to reduce fire risks.

## Chip Fuel Reclaim/Loading Options

The method of reclaiming chips depends on the storage option. For pile systems a boom drag system, underpile drag chain conveyor, auger, tube belt or tube screw conveyor can be used to load trucks for transportation. Front end loaders can also be used. For storage bins, live-bottom systems, augers or "moving hole" systems are commonly used to remove chips from storage. For silos, it is possible to have a truck drive through system in which chips are loaded by a live-bottom system, screw auger or gravity aided by a variety of other feed systems from the silo.

## Drying Options

Drying is an option that has significant capital and operations and maintenance (O&M) costs. It can have significant benefits for thermal efficiency in boilers, but is usually employed when lower moisture content is required for the boiler configuration, such as in suspension systems. A trade-off to consider is the reduction in pile management and fuel quality improvement versus the dryer installation and operating costs and environmental considerations.

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[11]Robert Rynk, "Fires at Composting Facilities: Causes and Conditions", *BioCycle* 41(1), January 2000, http://www.environmental-expert.com/magazine/biocycle/january2000/article4.htm

[12] Edward L. Springer, Should Whole-Tree Chips for Fuel be Dried Before Storage, USFS Forest Products Laboratory FPL-0241, http://www.fpl.fs.fed.us/documnts/fplrn/fplrn241.pdf

## 3.3 Central District Heating Plant

The model for the fuel supply requirements for a large industrial central district heating plant is Xcel Energy's Zuni Plant located in downtown Denver. This natural gas-fueled plant serves residential, commercial and industrial heating and cooling customers in downtown Denver and is part of the Denver District Steam system that also includes the Denver Steam Plant located at 1875 Delgany Street and a newly installed boiler located at the State of Colorado's Capitol Complex. In the 12 months ending March 31, 2005, the district heating system supplied approximately 828 million pounds (lb) of steam to customers. The Zuni Plant provided approximately 1/3 of this steam.[13] The Zuni Plant also provides power to the grid using one 45MW and one 76MW turbines, but not as baseload power.

### 3.3.1 Feedstock Quantity Required

The steam load is the most significant during the period from November 1 through April 15. Total fuel usage depends in part on how Xcel would reconfigure the plant to use wood. It is likely that Xcel would keep the original natural gas boiler systems. The natural gas boilers could then service the turbines to generate power and serve as backup for a new wood-fired heating system. If, however, Xcel decided to operate the turbines using steam from the wood-fired boilers in addition to serving district heating and cooling loads, fuel use would be higher. Fuel use would also depend on whether or not the plant is operated as a cogeneration facility. If useful heat is available for district heating and cooling after it exits the gas turbines, the amount of wood fuel required would decrease. We were not able to estimate potential reductions in fuel use due to cogeneration savings, because we cannot predict how much the Zuni Plant will be used for power generation. We assume that all of the energy required to meet the demand for heating and cooling is generated using wood. Therefore, our estimate of fuel requirements is likely somewhat high, which is a conservative approach. Steam load is growing by approximately 1 percent per year. We take this into account over a projected 20 year plant lifespan.

We also provided three scenarios: 1) Wood-fuel boiler serves district heating and cooling needs only, 2) New boiler serves district heating/cooling needs plus operates power plant if operated 20% of time at 90% capacity and 3) Boiler serves heating/cooling district plus operates power plant 90% of time at 90% capacity. Table 3-1 summarizes fuel use based on these scenarios.

**Table 3-1. Estimated Fuel Requirements for Large District Heating Application**

| Scenario | Fuel heat input (MMBtu/year) | Wood required (GT/year) |
|---|---|---|
| 1) Steam only (+ 20% for steam use growth at 1% per year) | 441,600 | 49,067 |
| 2) Steam + power (turbines produce power 20% of time) | 2,322,832 | 258,092 |
| 3) Steam + power (turbines produce power 90% of time) | 8,907,142 | 989,682 |

[13] Direct Testimony of Janice Wagner, Director of Thermal Energy and Zuni Generating Station, Xcel Energy Energy Supply Business Unit, Before the PUC of the State of Colorado, RE: Tariff Sheets Filed by PSCo with Advice Letter No. 94 – Steam, August 3, 2005, On-line: http://www.xcelenergy.com/docs/corpcomm/WagnerTestimony20050803.pdf

To develop the estimates in Table 3-1 , we estimated steam production for the Zuni Plant based on annual steam production of 276 million lb/year (1/3 of total Denver District Steam usage), assumed steam temperature of 202 degrees F and pressure 1,600 pounds per square inch absolute (psia), and 75% boiler efficiency[14]. Wood fuel assumptions included heat content of 9MMBtu/green ton, with fuel moisture content of 50% wet basis. To estimate fuel use for steam production and power generation, we assumed a plant nominal heat rate of 11,813 Btu fuel input per kWh of power generation based on the EPA April 2003 EGRID data for the Zuni Plant and an assumed overall availability of turbines of 90%.

Scenario 2 matches approximate fuel use inputs provided by the Xcel Energy Thermal Energy division manager Steve Kutska. In addition, this is consistent with recent permit changes for the Zuni Plant that suggest that the plant is operating more than simply as a peaking power plant.

### *3.3.2 Feedstock Specifications*

Table 3-2 shows typical ranges for fuel type, moisture content and particle size for common wood biomass combustors and gasifiers. Fuel type, fuel particle size distribution and fuel moisture content can all affect handling and processing systems, combustion completeness, thermal efficiency, and emissions of nitrogen oxides ($NO_x$), particulate matter and other air emissions. Ash content can affect ash handling systems and ash disposal costs. Overly stringy fuel such as bark from certain tree species can cause blockages in fuel handling and fuel infeed systems for boilers. Wood flour and other fine particulate matter can cause excess fugitive dust emissions and can pose fire risks in storage areas and boiler buildings.

**Table 3-2. Typical Fuel Specifications for Biomass Combustors and Gasifiers**

| | Technology | | | | |
|---|---|---|---|---|---|
| **Variable** | **Thin-pile spreader stoker** | **Underfire stoker** | **Fluidized bed combustion** | **Fixed bed gasifiers** | **Fluidized bed gasifiers** |
| Acceptable fuels | Sawdust, non-stringy bark, shavings, end cuts, chips, hog fuel | Sawdust, non-stringy bark, shavings, chips, hog fuel | Most except wood flour and stringy materials | Chips, hog fuel | Most except wood flour and stringy materials |
| Particle size (inches) | 0.2 - 2 | 0.2 - 1.5 | 2 maximum | 0.2 – 3.9 | 0.2 - 2 |
| Moisture content (%) | 10 - 50 | 10 - 30 | <60 | <20 | 15 - 65 |
| Ash (%) | <3 | <3 | <3 | Not available | Not available |

Source: Adapted from Phillip Badger, Processing Cost Analysis for Biomass Feedstocks, ORNL/TM-2002/199, Oak Ridge, Tennesee: Oak Ridge National Laboratory, October 2002.

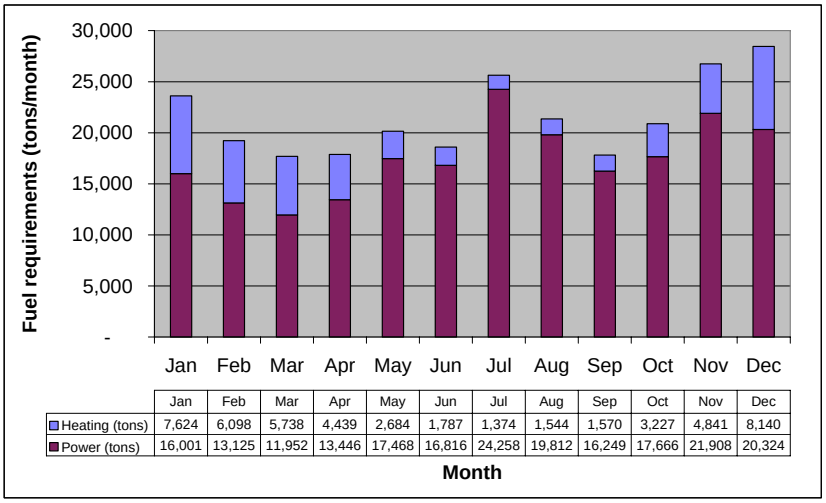
Fuel quality specifications are not absolute. Boiler and gasifier configurations can be modified to cope with less-than-optimal fuel quality, but these modifications can increase capital and operating costs and affect system performance. Fuel specifications are therefore inherently system-specific and should be evaluated during system engineering and design and reevaluated during the operational lifetime of the system.

[14] U.S. EPA EGRID 2003, data year is 2000. Ratio of useful heat output to total heat input is 74%.

### 3.3.3 Feedstock Delivery Schedule

The fuel schedule in any given month depends on heating and cooling loads that the boiler system services in downtown Denver and power generation demand on the plant. We did not have access to monthly fuel usage data for the Zuni Plant, so we employed an estimate of monthly fuel use for heating and power generation at the Zuni Plant based on EIA data on commercial and industrial natural gas use data for Colorado in 2005. We multiplied total wood fuel requirements for heating by the monthly percentage of commercial natural gas usage to develop monthly estimates of fuel use for the Denver District Steam system. Similarly, we multiplied total annual wood fuel use for power generation by the monthly percentage of electric utility natural gas use to develop monthly estimates of wood fuel use for power generation.

Figure 3-3 shows the outcome of our projections of monthly fuel requirements. Approximately 75 percent of the demand for wood fuel for heating occurs during the months from November through April. The remainder is used mostly for cooling requirements in the summer. The estimate of fuel use (both monthly and total annual) by the power plant is much more speculative, because we do not have data on when the Zuni Plant is needed to supplement other power resources for Xcel. We expect more variation in monthly fuel use for power generation, as a variety of factors influence Xcel's power requirements and subsequent use of the Zuni generation resource. As a result, we would recommend stockpiling fuel for several months to account for periods when demand at the Zuni Plant spikes due to factors not represented here.




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating (tons) | 7,624 | 6,098 | 5,738 | 4,439 | 2,684 | 1,787 | 1,374 | 1,544 | 1,570 | 3,227 | 4,841 | 8,140 |
| Power (tons) | 16,001 | 13,125 | 11,952 | 13,446 | 17,468 | 16,816 | 24,258 | 19,812 | 16,249 | 17,666 | 21,908 | 20,324 |

**Figure 3-3. Estimated Monthly Fuel Use for Heating and Power at the Zuni Plant**

Projected average monthly demand ranges from 11,952 tons in March to 21,908 tons in November, based on our estimates. At approximately 24 tons per truckload, truck traffic to the plant would range from approximately 500 to 1,000 trucks per month delivered to the facility (about 20 to 40 trucks per day). For heating alone, 200 to 400 trucks per month (7 to 13 trucks per day) would be required during the peak use periods from November through April.

Most forest biomass is generated during the period between April and November due to weather constraints. Urban residues are generated year-round, but more is also generated during late Spring through Fall. This suggests that material generated can be stockpiled during late spring through fall to meet usage for the heating season. Demand for landscaping products lags in the winter, which could provide an opportunity to improve year-round cash flow for wood recyclers.

### *3.3.4 On-site Fuel Receiving, Handling, Storage and Infeed Systems*

This section discusses wood fuel receiving and handling, storage, fuel reclaim and site configuration options for the Zuni site in downtown Denver.

**Site Description**

The Zuni Plant is located at 1335 Zuni St, Denver, CO 80204. Figure 3-4 presents an aerial view of the plant. The plant occupies an area of approximately 2.5 acres (125 by 80 meters) bounded on the west by the S. Platte River, on the east by Zuni St, and on the south by W. 13th Ave.


**Figure 3-4. Zuni plant detail with Denver parcel identification numbers**

Table 3-3 lists government jurisdictions that the Zuni plant falls within and neighboring districts.

**Table 3-3. Government and planning jurisdictions affected by Zuni plant development**

| Level of government/planning | Jurisdiction |
|---|---|
| City Council District/Representative | District 9, Judy Montero, 303-458-8960<br>Bordered by 1 to the northwest, Rick Garcia (303) 458-4792 rick.garcia@ci.denver.co.us and<br>District 3 to the southwest, Rosemary Rodriguez, 303-922-7755, rosemary.rodriguez@ci.denver.co.us |
| Blueprint Denver 2020 | Mixed use, with some industrial and some transit development |
| Denver Police District | District 1, 720-913-0400<br>Bordered by 6 on the east, 303-839-2100 |
| Denver Fire District | District 6, bordered by 2 on the east, 720-913-3473 |
| State House of Representatives District/Representative | District 5, Joel Judd, 303-866-2925, joel.judd.house@state.co.us<br>Bordered by 2 on the south, Mike Cerbo, 303-866-2911, michael.cerbo.house@state.co.us |
| State Senate District/Senator | District 31, Jennifer Veiga, 303-866-4861, jennifer.veiga.senate@state.co.us<br>Bordered by 34 on the west, Paula Sandoval, 303-866-4862, paula.sandoval.senate@state.co.us |

Source: City and County of Denver, Denver Maps, http://www.denvergov.org/denvermaps/report.asp?rpt=ccust&cat=ccust, accessed May 2, 2005.

## Wood Fuel Receiving and Handling Options

The wood fuel receiving and handling options available are similar to those at the processing and interim storage site, but the constraints are considerably different. The location is in an urban industrial area near downtown Denver, space constraints are more significant, appearance of the industrial facilities could be a significant factor due to the downtown location and the City and County of Denver is the location rather than Jefferson County, Colorado.

*Xcel Energy willingness to grant site access:* Currently the plant is fueled by natural gas with a natural gas backup. The plant site is not configured to accept solid fuels delivered by truck. If Xcel Energy does build a wood-fired plant, they will have to reconfigure their site to provide the infrastructure for a safe, efficient and cost-effective access for fuel delivery vehicles and provide access to the site that is compatible with the needs of the interim storage facility.

Prior to the formal proposal of a plant or development of engineering specifications for either the interim storage site or a wood-fired boiler system it would not be advisable for either party to agree to provide site access to the other party. However, once a plant is proposed and Xcel Energy moves forward with permit applications and preliminary conceptual design layouts, it is reasonable to expect that it is in Xcel Energy's best interest to commit to a mutually acceptable site access, unloading, measurement and pricing policy. In light of this, there are several steps that can be taken to allow investors/financiers to move forward with the interim storage facility and reduce the uncertainty regarding fuel delivery and cost for Xcel:

- Formal agreement by both parties committing to coordination between the design teams for the interim storage facility and plant design engineers for Xcel Energy;
- Development by Xcel of draft policies and procedures related to site access (delivery scheduling, hours of operation, vehicle types and weight limitations, vehicle idling, etc.);
- Providing draft policies and procedures to developers of the interim storage facility early in the project development phases for comments;
- Ongoing coordination of development of design and policy/procedure development throughout the project development stage.

*Access route and procedure:* The plant is accessed by a gate located on the east side of the facility. There is also an additional access road to the facility also located on the east side of the facility that is not used for site access. Figure 3-5 shows both of these existing access routes. The existing access road and plant entrance may not be utilized for the fuel supply if the supply is not stored immediately adjacent to the boiler house. A major site reconfiguration would be required to locate on-site storage immediately adjacent to the boiler house. It is more likely that an adjacent parcel would be redeveloped with a new access point to accommodate the security/guard station, truck scales and fuel storage. It is also possible that the existing boiler system will remain in its entirety as a backup for the new wood boiler system, in which case on of the adjacent parcels will be used for an entirely new heating plant.

There are a variety of adjacent parcels that are adequate in size for this use, including parcels immediately to the north of the existing boiler house. A subsequent section addresses in more detail the suitability of some of the adjacent parcels for this purpose.


Source: City and County of Denver, Denver Maps, http://www.denvergov.org/denvermaps/report.asp?rpt=ccust&cat=ccust, accessed May 2, 2005.

**Figure 3-5. Diagram of site access to Zuni Plant with approximate site dimensions**

There is also the potential for rail access to the site. There is a rail car line located approximately $^{1}/_{8}$ of a mile to the northwest across the S. Platte River, and a rail siding/rail line approximately ¼ mile to the east. An unused rail spur extends from the rail line on the east and crosses several private parcels including an oil supply company. One of these facilities could conceivably be extended and/or refurbished to the Zuni facility should rail delivery from an interim storage area be feasible. A new rail crossing would be required to cross Zuni from the existing unused rail spur, and several industrial enterprises would need to be relocated. The rail line located to the northwest runs parallel to a bike path adjacent to the plant, and could pose safety hazards to path users if used frequently for industrial applications. A separate access/security point and fuel unloading station would have to be built. Due to the urban location of the plant, construction of this additional rail access could be costly and result in significant impacts to multiple neighbors. A detailed engineering economic and legal analysis that is beyond the scope of this study would be required to assess the viability of this approach with any level of certainty.

Road access would likely by via West 6th Avenue. From West 6th Avenue the driver would take the CO-88 exit 0.2 miles, then turn left at Federal Blvd. and drive 0.3 miles, turn right at West 8th Avenue and go 0.5 miles then turn left onto Zuni St. and drive 0.6 miles. The entire route runs through industrial areas, with the only nearby residential development being a one-block development north of 9th Avenue, east of Decatur Street and west of the S. Platte River. This subdivision is the Sun Valley Homes development, a project of the Denver Housing Authority.

## Wood Fuel Storage Options

The plant site is occupied by existing plant equipment, including the boiler house, cooling towers, laboratory, fuel oil tanks (one 500 gallon no. 2 diesel oil, three 4 million gallon no. 6 fuel oil, one 300,000 gallon no. 6 fuel oil, and one 3,000 gallon no. 6 fuel oil), and other equipment

storage and on-site structures. There is little open area for fuel storage directly at the plant location. However, the plant itself is older, with two boilers originally put on-line in 1948 and a third in 1954.[15] It is possible that replacing the existing boilers with modern wood-fired boilers and reconfiguring the site could provide additional room on the site. However, it is more likely due to the need for site flexibility for construction and an adequate layout for fuel receiving and storage that an adjacent parcel would be developed for these purposes. It is a real possibility that an adjacent parcel will not just be used for fuel storage, but instead will be redeveloped into an entirely new boiler system, keeping the original system as a backup.

There are additional industrial parcels located to the north and south of the plant that could potentially be utilized for fuel storage and accommodate a new boiler system. Parcels located immediately north of the boiler house appear to be largely undeveloped except for parking and equipment storage (Figure 3-6). These parcels have the advantage of being contiguous with the existing plant. The parcel immediately north of the plant (0504212001000) is currently a parking lot for the plant, while seven parcels just north of that are currently used for trailer and equipment storage. The parking lot could be relocated and some or all of these parcels could be consolidated to provide room for a new facility including fuel storage and boiler systems, or the two could be split between parcels on the north and unoccupied portions of parcels south of W. 13th Avenue. These parcels have a combined area of 5.6 acres.


**Figure 3-6. Parcels north of Zuni Plant**

Parcels located south of the plant across W. 13th Ave but east of the S. Platte River (including a parcel east of Zuni St. not shown in Figure 3-7) could also be redeveloped. Fuel can be conveyed below street level if needed to avoid overhead conveyor systems if a street needs to be crossed. The parcel immediately south of the power plant is occupied by plant shops and cooling towers

[15] Jacqueline Joyce, August 2003 (Revised November 24, 2003), Technical Review Document for Renewal of Operating Permit 96OPDE134: Public Service Company, Zuni Station, Denver County, Source ID 0310007, Colorado Department of Public Health and Environment

but there is also a large area of unused space. The plot across Zuni St. is also largely unoccupied. These three parcels have a combined area of 7.2 acres.


**Figure 3-7. Parcels south of Zuni Plant**

Table 3-4 shows the ownership, zoning, size and assessed value of the parcels north and south of the Zuni Plant that are the most promising for redevelopment.

**Table 3-4. Parcels north and south and adjacent to Zuni Plant**

| Parcel ID | Owner | Zoning | Approximate size (sf) | Assessed value ($) |
|---|---|---|---|---|
| **Parcels north of plant** | | | | |
| 0504212001000 | Public Service Company | I2 | 128,000 | 1,006,400 |
| 0504211008000 | Union Pacific Railroad Co | PRV | 35,100 | 280,800 |
| 0504211011000 | Siegel Oil Co. | PRV | 64,099 | 292,600 |
| 0504211002000 | Weiss, Arvin | PRV | 3,125 | 25,000 |
| 0504211003000 | Weiss, Arvin | PRV | 3,125 | 25,000 |
| 0504211004000 | WW Enterprises | PRV | 3,125 | 25,000 |
| 0504211005000 | Weiss, Arvin | PRV | 6,250 | 50,000 |
| 0504211007000 | Union Pacific Railroad Co. | PRV | 2,210 | 17,700 |
| | | Subtotal not owned by PSCo | 117,034 (2.7 acres) | 716,100 |
| | | Total | 245,034 (5.6 acres) | 1,722,500 |
| **Parcels south of plant but east of S. Platte River** | | | | |
| 0504224002000 | Public Service Co. | I2 | 213,000 | 1,576,200 |
| 0504223006000 | City and County of Denver | I2 | 750 | 6,900 |
| 0504223008000 | Lanoha, Richard F. and David P. | I2 | 122,458 | 1,032,800 |
| | | Subtotal not owned by PSCo | 123,208 (2.8 acres) | 1,039,700 |
| | | Total | 336,208 (7.2 acres) | 2,615,900 |

Whether or not an adjacent parcel is redeveloped for fuel receiving and storage only or for an entirely new boiler system, silo storage can provide on-site storage with a relatively small footprint and limit fugitive dust emissions at the site. This option will cost more than open pile or partially enclosed pile storage, but could prevent a wide variety of issues associated with air

quality and other dust-related issues. An additional option is partially enclosed or in-ground fuel pit or bunker. Open pile storage is unlikely due to dust emissions and space constraints.

**Chip Fuel Unloading/Reclaim Options**

The chip fuel reclaim system used depends on the storage method employed. If a silo system is utilized, an auger live bottom system or a variety of other feed systems aided by gravity could be used to reclaim fuel. A silo may employ a chain flail or other similar device to avoid blockages or bridging in the silo. If an fuel bin or bunker is used, a live bottom, auger or moving hole system would be used to remove chips from storage.

**Site Layout and Configuration**

As stated previously, it is likely that the existing boiler system would remain in place as a backup for the new wood-fired system. Under this scenario the new fuel receiving, storage and boiler system would be located an on adjacent parcel to the existing plant, and steam from the wood-fired system could be used to replace or offset steam generated by the natural gas boilers used to generate electricity at peak periods.

## *3.4 Pellet Manufacturing*

The second end-use considered in detail is pellet manufacturing. There currently are no pellet manufacturing plants located in Colorado, and there is significant interest in developing one or more plants to meet growing residential demand and possibly break into commercial and industrial heating markets.

### *3.4.1 Feedstock Quantity Required*

The size of the pellet facility can be adjusted to match the available resource and markets, but a general rule of thumb is that a facility must produce approximately 20,000 tons of pellets each year due to economies of scale. Most facilities are somewhat larger. Many pellet mills range in capacity from 4 to 8 dry tons per hour, or about 30,000 to 60,000 dry tons of debarked wood per year. Assuming 45 percent as received wood moisture content and 15 percent bark content of the raw material, wood requirements would range from approximately 57,000 to 114,000 tons of green logs with bark per year. If the facility receives clean chips, it could require less material. However, it will have to use a conventional fuel for drying the chips. If the facility produces pellets for the commercial or industrial market, it could potentially use the entire log including bark or barky chips, because pellet ash content requirements could be less stringent than the residential market. Using clean, urban wood waste such as trim ends or truss manufacturing residues could reduce total requirements because these residues have lower moisture content. Section 3.3.2 discusses feedstock specifications in more detail.

### *3.4.2 Feedstock Specifications*

A pellet facility's fuel specification depends on the end market. For residential markets, the facility has to meet strict ash content standards (typically less than one percent). It may use whole logs as the raw material, and debark them on-site to meet this ash content. It can also use whole logs that have been debarked in the forest using a chain-flail debarker. Material can then be ground to less than ¼ inch diameter for use in the palletizing process. Bark can be sold or used in a dryer to dry the ground material to less than 10-12 percent moisture, as needed by the

pelletizing process. Alternatively, a debarking chipper can provide clean chips delivered to the site. Relying exclusively on this supply source would limit the suppliers to those that own and operate debarking chipping equipment, a capital-intensive piece of equipment.

### *3.4.3 Feedstock Delivery Schedule*

Unlike an industrial heating facility, a pellet mill operates consistently on a year-round basis. Therefore, depending on the size of the facility, each month the facility will require approximately 4,800 to 9,500 wet tons per month, slightly less if debarked chips are used or if a portion of the supply comes from dry wood waste. To meet this level of demand, approximately 200 to 430 trucks per month would arrive at the facility (assuming 23 tons/truck). On a daily basis there would be 7 to 14 truckloads if the facility receives material on a consistent schedule throughout the year. Assuming the window for supplying forest biomass is limited, the facility could receive twice this number of trucks per day or more at peak periods.

## *3.5 Bioethanol Manufacturing*

Power Energy Fuels Inc. (PEFI) is proposing constructing a pilot bioethanol plant at Jefferson Research Center I located at 18300 W. Highway 72, Arvada, Colorado.

### *3.5.1 Feedstock Quantity Required*

The plant would initially produce only 100 to 500 gallons per day and require about one ton of feedstock per day, but phase two of the proposed facility would be to build a 200 ton per day plant (bone dry) and produce alcohol fuels. This converts to approximately 65,000 dry tons of material per year if the facility operates 90 percent of the time. Assuming 45 percent moisture, the plant would use approximately 120,000 green tons per year.

### *3.5.2 Feedstock Specifications*

The feedstock specifications are not identified, but the process being considered can use a wide variety of feed stocks including barky chips. The facility could probably accept both material in log form, which can be stored for longer periods than wet chips, and chips. The preferred moisture content for the technology is 35 percent or below.

### *3.5.3 Feedstock Delivery Schedule*

This facility would operate consistently on a year-round basis. Each month the facility will require approximately 10,000 wet tons per month, slightly less if debarked chips are the raw material or if a portion of the supply comes from clean, dry wood waste. This is approximately 400 trucks per month (assuming 23 tons/truck) or 14 truckloads per day if the facility receives material on a consistent basis throughout the year. Assuming the harvest window for supplying forest biomass is more limited, the facility could receive two times this number of trucks per day.

### *3.6 Feedstock Processing/Storage Needs for Energy and Fuel Manufacturing*

Table 3-5 compares feedstock quantity and other requirements for the various end uses being considered for this study.

**Table 3-5. Comparison of Facility Feedstock Requirements**

| Variable | District heating | Pellets (Production of 4 to 8 dry tons/hour) | Bioethanol |
|---|---|---|---|
| Fuel needs | | | |
| GT/year | ~50,000 (steam only)<br>~260,000 (steam + power) | ~57,000 – 114,000 | ~120,000 |
| GT/day | ~140 (steam only)<br>~700 (steam + power) | ~170 - 328 | ~365 |
| Type of fuel | Chips | Whole logs or clean chips preferred | Whole logs or chips |
| Fuel moisture | Low as possible | Low as possible | Below 35% preferred |
| Trucks/day (peak) | 26 (steam only)<br>65 (steam + power) | 14 - 26 | 28 |
| Seasonality | 75% Nov – Apr<br>25% May – Oct | Consistent throughout year | Consistent throughout year |

Notes: Assuming 45% feedstock moisture content and that facility operates 90% of time in year. Usage in tons per day reflects use per operating day.

We developed equipment configurations, estimated capital and operating costs, evaluated siting issues and permitting requirements for biomass receiving, storage and processing facilities sized to meet these feedstock requirements. Section 4 discusses the results of these efforts.

# 4 SITING ANALYSIS

This section describes equipment requirements and costs, site requirements, likely environmental issues, and permit needs for siting a biomass storage and processing facility in Jefferson County.

## *4.1 Equipment Requirements and Costs*

Because each facility has slightly different requirements, we developed several equipment configurations with preliminary cost estimates based on published data;

1. 60,000 ton per year capacity chip plant suitable for small pellet plant.
2. 120,000 ton per year capacity chip plant suitable for large pellet plant or scale-up bioethanol facility.
3. 260,000 ton per year capacity chip plant suitable for cogeneration operation serving district heating system and supplemental power plant used to run 101MW turbines 20% of time. This presumes that biomass power is dispatchable to meet peak needs on Xcel's system, which can only determined through a more detailed engineering analysis.

Equipment requirements and costs for each of these are discussed in more detail below.

Table 4-1 provides estimates of the storage area requirements for large district heating (both at the central wood processing facility and on-site at the combined heat and power (CHP) facility), a pellet facility and a biomass ethanol plant based on peak daily use by each plant. Notably, for the peak daily use for the district heating plant, usage is less at the processing facility than at the power plant, because the processing facility can accept material year-round while the power plant uses most of the fuel during winter months. The storage pile shape for a log pile is roughly rectangular, with a maximum height of 20 feet. The shape for a chip pile used to calculate storage area was a truncated pyramid with sides of no more than 45 percent slope.

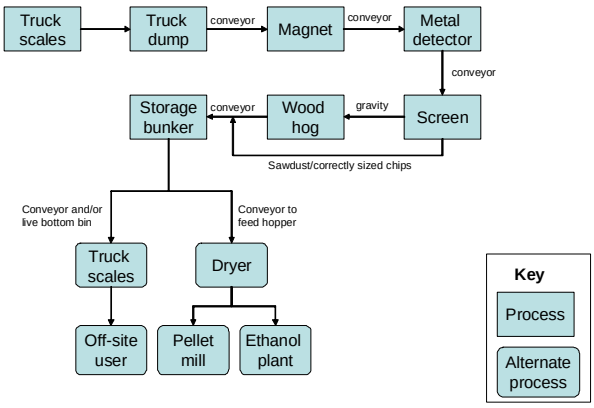
**Table 4-1. Storage area requirements**

| Variable | Central heating + supplemental power | | Pellets | Ethanol |
|---|---|---|---|---|
| | Central storage/processing | Cogen plant | | |
| Days of storage required | 90 | 3 | 90 | 90 |
| Peak daily intake (tons) | 538 | 863 | 131 | 274 |
| Peak daily intake (cy solid wood) | 1,792 | 2,875 | 438 | 913 |
| Storage needed (cy solid wood) | 161,308 | 8,625 | 39,420 | 82,125 |
| Fuel composition (% Logs) | 50% | 0% | 75% | 25% |
| Fuel composition (% Chips) | 50% | 100% | 25% | 75% |
| Log volume - including air (cy) | 134,423 | - | 49,275 | 34,219 |
| Chip volume - including air (cy) | 268,846 | 28,751 | 32,850 | 205,313 |
| Area required (acres) | | | | |
| Log storage | 4 | - | 2 | 1 |
| Chip storage | 7 | 0.5 | 1 | 5 |
| Roads/receiving/overflow | 3 | 0.2 | 1 | 2 |
| Chipper/landing | 1 | 1 | 1 | 1 |
| Total | 15 | 2 | 5 | 9 |

Note: cy = cubic yards
Assumptions: chip pile solid wood factor = 30%, log pile solid wood factor = 60%

The type of storage area required is partly dictated by technical issues and partly by economic issues. For a large central processing/storage facility that would serve a large district heating facility, a partially below grade bunker with 3-walls to reduce dust blowing for a large, central storage facility. Having an entirely closed structure or one with a roof may be cost-prohibitive for a facility of this size. At the CHP plant, space constraints and ease of loading/unloading would dictate that concrete or metal silo storage be used. For a pellet or ethanol facility, a partially below-grade bunker would be appropriate. The economics may permit a three-walled structure to cover at least a portion of the pile to reduce fugitive dust emissions.

Figure 4-1 shows a typical process flow with major process components for the storage and processing facility. Facilities will vary on this theme in terms of the type of receiving method (e.g., trailer dump vs. whole truck dump vs. live-bottom trailer pit or any combination thereof), conveyance method, storage (e.g., open pile vs. silo, bunker and/or three-walled shed with roof and similar variations) and other components. These systems will ultimately be defined in the engineering design for the facility.




Source: Adapted from Phillip C. Badger, October 2002.

**Figure 4-1. Typical process flow diagram for biomass storage and processing**

The size and capacity of various components will vary depending on the facility's requirements. The central processing plant for CHP would require two high-capacity chippers/grinders vs. one for other options. The system engineers may want to have more than one of these components to have redundancy in case the primary machine breaks down. For purposes of this study we assumed that the storage facility at the CHP plant would not be equipped with regrind equipment, screens/magnets. This assumes that the central processing facility will meet all fuel specifications for the plant. Addition of this equipment at a modest cost could reduce fuel infeed system failures and improve plant reliability.

We assume that the fuel suppliers will haul material to the facility and/or the facility will contract with haulers on an as-needed basis. However, it would be prudent for the facility to have at least one tractor trailer/chip van combination to use to move material around the facility or to make up for contractor breakdowns. Ethanol and central processing facilities may want to have more trucks/tractor trailer combinations on-site to fill in for equipment gaps and/or move material on-site as needed. In our capital cost estimates we assumed three tractor/trailer combinations for these facilities versus one for a pellet plant and for the CHP plant itself.

Table 4-2 presents estimated truck traffic for each facility type. This information is useful to support assessment of truck traffic impacts on the area. It also provides guidance for how large a supply area is feasible given a number of tractor trailers used by fuel supply contractors.

**Table 4-2. Truck /fuel delivery requirements**

| Variable | Central heating + supplemental power | | Pellets | Ethanol |
|---|---|---|---|---|
| | Delivered to central storage/processing | Delivered to CHP plant | | |
| Peak daily use (tons) | 538 | 863 | 131 | 274 |
| Peak monthly use (tons) | 16,131 | 25,876 | 3,942 | 8,213 |
| Trucks/month (peak) | 701 | 1,125 | 171 | 357 |
| Trucks/day (peak) | 23 | 38 | 6 | 12 |
| Number of trucks available* | 10 | 6 | 2 | 4 |
| Loads per hour required | 1.95 | 3.13 | 0.48 | 0.99 |
| Max round-trip haul time including load/unload (minutes) | 268 | 75 | 212 | 202 |
| Max distance to plant (miles) | 78 | 22 | 62 | 59 |

Assumptions: Truck capacity = 23 tons, unload time = 20 minutes, hours of truck operation/day = 12, average road speed = 35 mph

The estimated number of truckloads arriving at the storage and processing facility ranges from a low of six for a small pellet manufacturing facility to a high of 23 for a central district heating plant. Notably, the number of trucks leaving the central storage facility each day to drive to a district heating plant is higher than the daily average arriving at the storage facility. This is because fuel use is concentrated in the winter months. Therefore the outgoing truck traffic is larger on a daily basis during peak fuel use periods in the winter.

If the number of trucks available increases, so does the ability of the driver to move further out to obtain fuel. It could also increase fuel costs, as suppliers need to support more trucks. With the current assumptions employed in Table 4-2, the district heating plant can meet its needs using wood fuel hauled from nearly 80 miles if ten trucks are delivering fuel. An additional six trucks are required by the facility to bring fuel from storage to the plant, if the district heating facility is 22 miles from the storage facility. The pellet and ethanol facilities are able to meet their requirements using two and four trucks, respectively, as long as the feedstock is within approximately 60 miles of the facility. These calculations can help fuel suppliers with capacity planning, and can assist end users with determining what their realistic supply would be by establishing a feasible hauling radius, taking into account the capacity of regional suppliers.

We broke down costs into development, engineering, equipment, bulk commodities and construction and other categories. In addition, we assumed a 15 percent contingency value for the total project cost. Table 4-3 breaks down equipment cost estimates for the facility.

Table 4-3 shows estimated total project costs for the various scenarios, while Figure 4-2 shows the estimated cost breakdown using the central heating facility as an example. These project costs are strictly budgetary estimates. Site-specific capital costs will have to be determined through site-specific engineering estimates. It should be noted that it is possible that multiple biomass storage and processing facilities could serve the capital cost requirements for one or all of these facilities could be significantly reduced.

**Table 4-3. Equipment Cost Estimates**

| | | Heating | | | Pellets | | | Ethanol | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Unit of quantity | Quantity | Rate ($/unit) | Cost ($) | Quantity | Rate ($/unit) | Cost ($) | Quantity | Rate ($/unit) | Cost ($) |
| Truck scales/receiving | EACH | 1 | 110,000 | 110,000 | 1 | 110,000 | 110,000 | 1 | 110,000 | 110,000 |
| Truck dump | EACH | 2 | 300,000 | 600,000 | 2 | 125,000 | 250,000 | 2 | 125,000 | 250,000 |
| Drag chain feeder | EACH | 1 | 20,000 | 20,000 | - | 20,000 | - | - | 20,000 | - |
| Conveyor | EACH | 1 | 50,000 | 50,000 | 1 | 50,000 | 50,000 | 1 | 50,000 | 50,000 |
| Screens/magnets | EACH | 1 | 100,000 | 100,000 | 1 | 40,000 | 40,000 | 1 | 100,000 | 100,000 |
| Hammer hog | EACH | 2 | 150,000 | 300,000 | 1 | 50,000 | 50,000 | 1 | 150,000 | 150,000 |
| Conveyor - for regrinds | EACH | 1 | 25,000 | 25,000 | 1 | 25,000 | 25,000 | 1 | 25,000 | 25,000 |
| Drag chain reclaim | EACH | 1 | 25,000 | 25,000 | 1 | 25,000 | 25,000 | 1 | 25,000 | 25,000 |
| Conveyor -reclaim | EACH | 1 | 50,000 | 50,000 | 1 | 50,000 | 50,000 | 1 | 50,000 | 50,000 |
| Front end loaders (9 cubic meter bucket) | EACH | 1 | 230,000 | 230,000 | 1 | 230,000 | 230,000 | 1 | 230,000 | 230,000 |
| Truck tractors | EACH | 3 | 75,000 | 225,000 | 1 | 75,000 | 75,000 | 3 | 75,000 | 225,000 |
| Truck trailers | EACH | 3 | 25,000 | 75,000 | 1 | 25,000 | 25,000 | 3 | 25,000 | 75,000 |
| Building | $/SF | - | 10 | - | 12,763 | 10 | 127,628 | - | 10 | - |
| Bunker/foundation | $/SF | 49,131 | 4.45 | 218,631 | 10,168 | 4.45 | 45,245 | 43,548 | 4.45 | 193,787 |
| Miscellaneous | NA | NA | 150,000 | 150,000 | NA | NA | 75,000 | NA | 150,000 | 150,000 |
| **Total** | | | | **2,178,631** | | | **1,177,873** | | | **1,633,787** |

**Table 4-4. Estimated Total Project Cost Summary**

| Cost Category | Central heating | Pellet plant | Ethanol |
|---|---|---|---|
| Development | 263,400 | 205,000 | 263,400 |
| Engineering | 128,000 | 86,000 | 128,000 |
| Equipment | 2,178,631 | 1,177,873 | 1,633,787 |
| Bulk commodities | 230,000 | 190,000 | 230,000 |
| Other | 483,932 | 368,894 | 456,689 |
| Contingency | 492,594 | 304,165 | 406,781 |
| Total | 3,776,557 | 2,331,932 | 3,118,657 |

Capital equipment costs make up 58 percent of total project costs for a fuel processing facility that would serve a central district heating plant. Capital equipment costs in other scenarios make up a slightly smaller proportion of project costs for other scenarios.

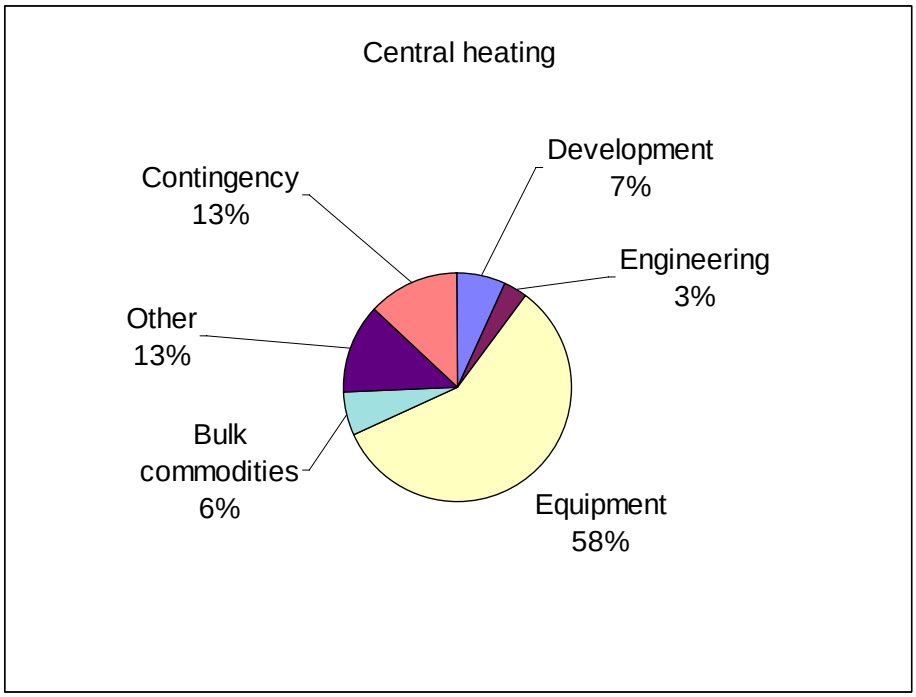



**Figure 4-2. Central Heating Plant Fuel Processing and Storage Facility**

Table 4-5 provides estimated labor and other O&M costs for each facility, based on raw material costs, published area labor rates and preliminary utility use costs. Appendix A provides a more detailed breakdown of all capital and O&M cost estimates for each scenario.

**Table 4-5. Estimated Annual Operating and Maintenance Costs for Biomass Facilities**

| Cost | Unit | Central heating | | | Pellets | | | Ethanol | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Quantity | Rate ($/unit) | Cost ($) | Quantity | Rate ($/unit) | Cost ($) | Quantity | Rate ($/unit) | Cost ($) |
| **PROPERTY TAXES** | $/year | NA | NA | **20,000** | NA | NA | **20,000** | NA | NA | **20,000** |
| **LAND LEASE** | $/acre | 10 | 20,000 | **200,000** | $/acre | 10 | **200,000** | 10 | 20,000 | **200,000** |
| **INSURANCE** | $/year | NA | NA | **15,000** | NA | NA | **15,000** | NA | NA | **15,000** |
| **SPARE PARTS** | $/year | NA | NA | **150,000** | NA | NA | **150,000** | NA | NA | **150,000** |
| **RAW MATERIAL** | BDT | 129,046 | 60 | **7,742,772** | 31,536 | 60 | **1,892,160** | 65,700 | 60 | **3,942,000** |
| **LABOR** | | | | | | | | | | |
| Plant Manager | $/year | 1 | $137,058 | 137,058 | 1 | $137,058 | 137,058 | 1 | $137,058 | 137,058 |
| Deputy | $/year | 1 | $71,070 | 71,070 | 1 | $71,070 | 71,070 | 1 | $71,070 | 71,070 |
| Operators | $/year | 12 | $60,119 | 721,431 | 6 | $60,119 | 360,716 | 6 | $60,119 | 360,716 |
| Fuel Handling | $/year | 3 | $60,119 | 180,358 | 3 | $60,119 | 180,358 | 3 | $60,119 | 180,358 |
| Maintenance | $/year | 3 | $57,676 | 173,029 | 3 | $57,676 | 173,029 | 3 | $57,676 | 173,029 |
| Administration | $/year | 1 | $43,243 | 43,243 | 1 | $43,243 | 43,243 | 1 | $43,243 | 43,243 |
| **Subtotal** | | | | **1,326,190** | | | **965,475** | | | **965,475** |
| **TRAVEL** | $/trip | 40 | 400 | **16,000** | 40 | 400 | **16,000** | 40 | 400 | **16,000** |
| **G&A** | $/hour | 500 | 100 | **50,000** | 500 | 100 | **50,000** | 500 | 100 | **50,000** |
| **UTILITIES** | | | | | | | | | | |
| Electricity | kWh | 5,429,468 | 0.07 | 380,063 | 3,213,327 | 0.07 | 224,933 | 3,989,782 | 0.07 | 279,285 |
| Natural gas | therm | 200 | 7.00 | 1,400 | 200 | 7.00 | 1,400 | 200 | 7.00 | 1,400 |
| Diesel | gal | 30,000 | 2.75 | 82,500 | 15,000 | 2.75 | 41,250 | 20,000 | 2.75 | 55,000 |
| Gasoline | gal | 1,000 | 2.75 | 2,750 | 1,000 | 2.75 | 2,750 | 1,000 | 2.75 | 2,750 |
| Water | gal | 557,000 | 0.00 | 1,365 | 557,000 | 0.00 | 1,365 | 557,000 | 0.00 | 1,365 |
| Wastewater | gal | 543,500 | 0.00 | 1,631 | 543,500 | 0.00 | 1,631 | 543,500 | 0.00 | 1,631 |
| Waste disposal | cy | 20,000 | 2.00 | 40,000 | 10,000 | 2.00 | 20,000 | 15,000 | 2.00 | 30,000 |
| **Subtotal** | | | | **509,708** | | | **293,328** | | | **371,430** |
| **MISCELLANEOUS** | **$/year** | | | **150,000** | | | **150,000** | | | **150,000** |
| **CONTINGENCY** | **$/year** | | | **1,526,951** | | | **562,794** | | | **881,986** |
| **TOTAL** | **$/year** | | | **11,706,621** | | | **4,314,757** | | | **6,761,890** |

## *4.2 Site Infrastructure Requirements*

The slope/topography of the site should be relatively level and/or permit grading as needed to level site for installation of concrete pads, chip storage piles and processing equipment. At the former Rooney Road landfill site there are few grading restrictions, although grading on the former landfill site would not be possible (although the proposed site does not include area on top of the former landfill) and restrictions related to grading in proximity to interstate highways should be investigated further. Possible soil contamination issues and possible remediation requirements at the Jefferson Research I, a former industrial site, should be evaluated in terms of possible unanticipated site development costs and liabilities.

Municipal water and wastewater processing are not available at the former Rooney Road landfill site. Water and wastewater at the Jefferson Research I Center are provided by the Jefferson Center Metropolitan District. Water requirements for the facility are required for fire and dust suppression, landscaping, and employee drinking water and related personnel needs. If necessary, composting toilets and similar equipment can take the place of municipal sewer and tanks can be used for process needs, dust and fire suppression. Chipping and pellet manufacturing have limited process water needs.

Electricity utility services are adequate and/or easily expandable to meet site requirements at both the Rooney Road landfill and Jefferson Research I sites. At the Rooney Road site, access will probably require upgrading and/or relocating an existing road that connects to the county-maintained road providing access to the former Rooney Road Landfill. This road crosses an Xcel Energy transmission right-of-way. Xcel Energy engineers provided some general guidelines that a facility should follow when configuring road access to the site. If a private developer builds the facility, it will need to negotiate a license agreement with Xcel to cross their property. Xcel's encroachment application and standard license agreements are included in Appendix B. If it is the county, an easement may be needed. The developer will need to develop a grading plan and submit it for review to Xcel. The key issue with grading is to ensure that horizontal and vertical clearance requirements are met. In general, there will need to be at least 20 feet horizontal clearance from the tower. However, the closer the road is to the tower, the easier it will be to meet vertical clearance requirements of at least 30 to 35 feet from the lines. Any facility or structure should be designed so that any equipment such as truck dumps, silos or other facility that could potentially fail should be far enough away from the towers so that if it were to fall, there is a minimal potential to impact towers or lines.[16]

Compatible land use and neighbor issues are significant for any such facility. It is preferable to site the facility in an industrial location where there are few likely conflicting land uses. This poses a greater potential issue for the former Rooney Road landfill site due to the proposed soccer field complex and potential viewshed issues related to visibility of the site from I-70, I-470, Green Mountain and Lookout Mountain. The road curvature and slope could provide an adequate means to obscure potential highway viewshed issues. The private land parcel portion of the Rooney site is zoned agricultural rather than industrial, and will require rezoning prior to development.

[16] Harry Swinhart, Xcel Energy, 303-571-7292, personal communication with Tim Rooney, June 13, 2006.

The Jefferson Research I facility has fewer viewshed issues, but a high-end residential development could be located across Highway 72 that could pose long-run potential neighbor issues. The local topography at this site will hide most visible equipment. This site is near an existing BFI landfill and A1 Organics which makes compatibility of land use less of an issue.

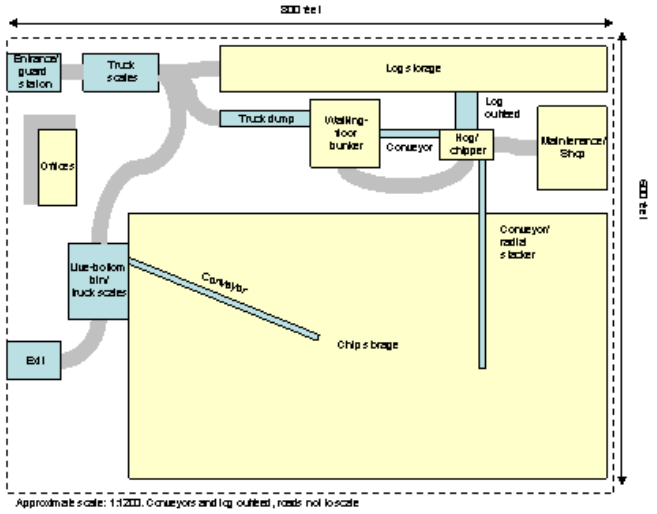
## *4.3 Site Layout*

Precise site dimensions, layout and systems must be the subject of a more detailed engineering design effort. Many aspects of development are site-dependent. The next steps of the engineering design process include performing detailed engineering computations to determine if the conceptual design can meet operational and safety/environmental performance objectives. These computations are used to modify the conceptual design until these and other objectives are met. Then the detailed design is used to produce drawings taking into account elevation contours and other site factors. Additional computations are conducted to ensure performance and regulatory requirements are met by the proposed design.[17]

Figure 4-3 through Figure 4-5 show general layouts for chip plants designed to produce and store adequate feedstock to supply a central district heating plant, small pellet manufacturing plant and ethanol plant, respectively. The chip storage areas are scaled to match the requirements specified in prior sections. These site layouts are all based on an 11 acre parcel. This is feasible because palletizing and ethanol equipment can be fit into the area occupied by a larger chip storage pile in the chip plant designed to supply the district heating plant. There is little room for facility expansion in these site layouts. Any potential facility should consider the potential for facility expansion in the acquisition and development of a particular site.

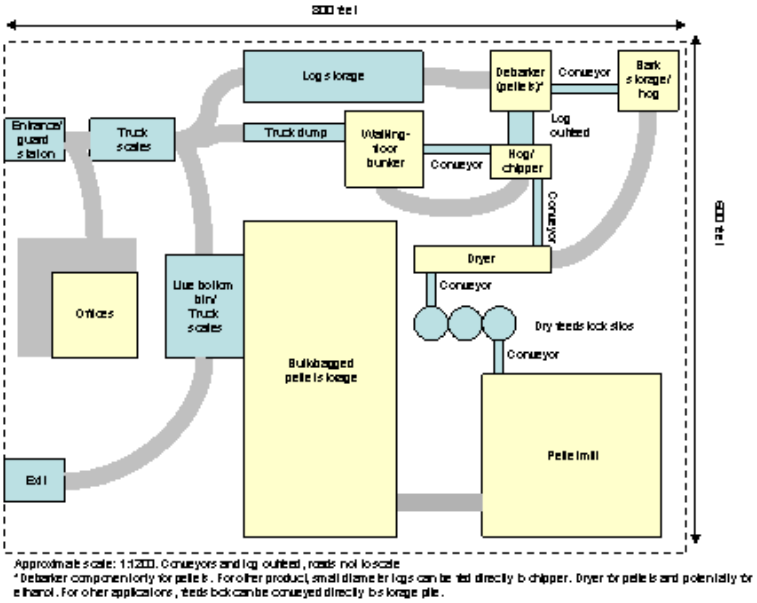
The "starting" point for each site is an entrance/guard station and truck scales, where incoming trucks are weighed full upon entry and empty upon leaving. The district heating plant layout has a separate scale area where trucks loaded to go to the central heating plant can be filled and weighed as they leave. Log storage piles provide a place where logs can be stored for a period of months or even more than a year until they are needed, when they can be chipped and used by the facility. Each of the site layouts includes a separate pile for log and chip storage. Each site is equipped with a truck dump area, followed by a temporary chip bunker where materials are held until they are conveyed into the chipper/grinder system. Chips are then conveyed into the chip storage area. For the pellet mill and ethanol scenarios, equipment is included for each of these processes and for storing, weighing and shipping the final product.

[17] Daniel P. Duffy, "Landfill Design: the Matrix Approach", *MSW Management*, March/April 2005, http://www.mswmanagement.com/mw_0503_design.html



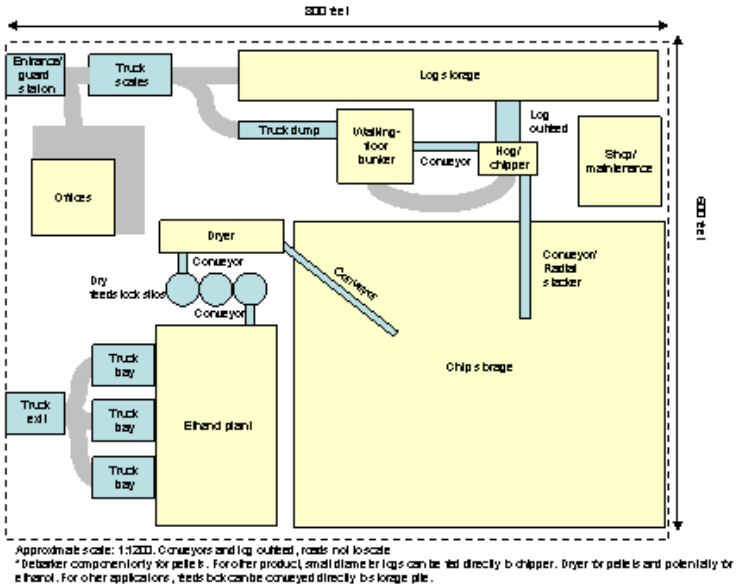

Concept from Gas Technology Institute, Calla Energy Biomass Cofiring Project Final Technical Progress Report Phase I, Des Plaines, IL: September, 2003

**Figure 4-3. General Layout for Chip Plant to Support District Heating Plant**




Concept from Gas Technology Institute, Calla Energy Biomass Cofiring Project Final Technical Progress Report Phase I, Des Plaines, IL: September, 2003

**Figure 4-4. General Layout for Pellet Mill and Chip Plant**




Concept from Gas Technology Institute, Calla Energy Biomass Cofiring Project Final Technical Progress Report Phase I, Des Plaines, IL: September, 2003

**Figure 4-5. General Layout for Ethanol and Chip Plant**

## *4.4 Environmental and Community Impacts*

Particulate matter (from wood storage and truck traffic), increased truck traffic and noise are the most significant issues associated with a biomass processing and storage facility. Particulate matter from chip storage piles can be managed by appropriate engineering (e.g., facility orientation, grading) and choice of storage structure (partial pile storage below grade, roofing and walls), erosion control, pile configuration and other management efforts. Particulate emissions from trucks is harder to control but appropriate road construction and traffic control methods can help minimize dust from trucks. The size of the facility will determine the amount of traffic it receives, but we would expect that the range would be from 6 to as much as 25 truckloads per day. The greater number is the case if a single site served all of the needs of a large central district heating system such as Zuni. Multiple sites are more likely, due to the large material requirements of such an end user.

Storm water management and leachate management are important due to the potential to contribute nitrogen and phosphates to surface and groundwater. These aspects will have to be addressed for facility permitting and can be done so responsibly through professional geotechnical design and engineering of the site to provide appropriate grading, surface channeling, collection, erosion control and monitoring.

## 4.5 Permitting

The primary permits required are related to air emissions and water quality issued by the State of Colorado and building permits issued by Jefferson County. These permits, permitting processes, timeframes and costs are described in the following subsections.

### 4.5.1 Colorado Construction (Emissions) Permits

The Construction Permit Unit (CPU) of the Colorado Department of Public Health and Environment (CDPHE), Stationary Sources Program issues construction (emissions) permits. The CPU evaluates the application for completeness, a preliminary analysis is conducted, public comments are sought and collected and a permit is issued. Time frames vary dependent on if public notice is required. If public notification is not required, a permit can be issued within 150 days. If public notification is required, a permit can be issued within 195 days.

Construction (emissions) permit process steps include the following:

- Submit Air Pollution Emission Notice (APEN). APEN is required for uncontrolled actual emissions of any criteria pollutant equal to or greater than two tons per year in attainment areas or one ton per year in non-attainment areas (http://www.cdphe.state.co.us/ap/downpermitforms/APENGeneral.doc); and
- Construction Permit Application
    - Submit Construction Permit application form (http://www.cdphe.state.co.us/ap/downpermitforms/Application.doc);
    - Submit notification of start-up (http://www.cdphe.state.co.us/ap/downpermitforms/NoticeStartup.doc);
    - Submit an addendum for non-criteria reportable pollutants if facility will have such emissions (http://www.cdphe.state.co.us/ap/downpermitforms/AddendumNCRP.doc).
    - Self-certification and final approval (SEE BELOW)

Public notification of construction permit applications is required for the following cases:

- Sources where annual emissions of any pollutant with ambient air quality standards are designated are above 25 tpy in non-attainment areas and 50 5py in attainment areas;
- Where preliminary analysis by CDPHE finds that there may be a possible violation of Commission Regulation No. 2 (odor); or
- Sources seeking federally enforced emission limits to avoid major source status.

Self-certification and Final Approval of Permits is required by CDPHE within 180 days of issuance of an initial approval permit. This process requires that the permittee:

- Demonstrate compliance with initial permit approval within 180 days after the start of operation; self-cert package is on the website; and
- Demonstrate that all conditions of initial permit are met.

The processing schedule for a construction permit is typically less than 150 days without public comment and 195 days with public comment. The permit schedule is typically as follows:

- Completeness determination – 60 days
- Preliminary Analysis – 60 days
- Public Notice (if required) – 15 days

- Duration of Public Comment Period – 30 days
- Permit issued – 30 days

For more information, contact Chip Hancock, permit engineer, 303-692-3168 or visit the CDPHE online: http://www.cdphe.state.co.us/ap/airpermits.html.

Additional permits that may be required include a mining permit for fugitive dust. An operating permit is required for facilities producing more than 100 tons per year of air emissions.

### *4.5.2 Colorado Water Quality Permits*

The three major water quality permit types that may be required by the CDPHE Water Quality Control Division's Permitting Unit include

- Stormwater construction permit, which regulates the amount and type of pollutants that can cause stormwater contamination during the construction process;
- Industrial stormwater permit, which requires development and approval of a stormwater management plan; and
- Industrial wastewater permitting (probably related to power washing and/or minimal discharge permits).

More information about stormwater permitting is available from the Permitting Unit on-line: (http://www.cdphe.state.co.us/wq/PermitsUnit/wqcdpmt.html#Stormwater). Additional information about all industrial wastewater processing permits is also on-line at: http://www.cdphe.state.co.us/wq/PermitsUnit/wqcdpmt.html#Industrial%20and%20Domestic. More information about the water quality permitting process and other related information is available on-line as well, at: http://www.cdphe.state.co.us/wq/PermitsUnit/wqcdpmt.html.

### *4.5.3 Jefferson County Permitting Process*

The land use process for Jefferson County Planning & Zoning includes:

- Pre-application review (recommended)
- Site approval (only for public or semi-public facilities that do not comply with the underlying zoning district – could apply to Rooney Road site),
- Site development plan (ensures compliance with plat or exemption from platting, zoning, and compliance with a variety of regulatory issues)
- Permit issuance (reviews all information related to development request.

Each step is discussed below, and forms and instructions are available from the Jefferson County Planning and Zoning department (http://jeffco.us/planning/planning_T59_R26.htm). A checklist of the requirements to obtain a building permit can be accessed online (http://jeffco.us/jeffco/planning_uploads/apps_handouts/building_permit_checklist.pdf )

**Pre-Application Review (30 days)**. This step is not required but is recommended prior to submitting a formal application. This is particularly important for the site of Rooney Road as it is currently zoned A-2 for agricultural use as this will require rezoning. After submittal, Jefferson County planning and zoning staff will review the application which is followed by a meeting with the applicant. This is followed by a review response summary from the county that summarizes all comments at meeting and provides a list of official application requirements, documents and fees. There is no fee for the Pre-application review process.

*Requirements:*

- Cover letter (10 copies)
  - Name, address, phone of property owner
  - Existing zoning
  - Synopsis of proposed use of property
  - Description of access to property
- Vicinity map (10 copies)
  - Directional map indicating how to get to property
  - Jefferson County personnel will tour the property
- Copy of Assessor's Parcel ID Map (available from Jefferson County website)
- Scaled Site Plan (10 copies)
  - Include north arrow
  - Date of preparation
  - Street and right-of-way widths
  - Grades
  - Designation of public or private
  - Access points
  - Parking
  - Wells or septic leach fields
  - Easement and utility lines
  - Lot dimensions
  - No build areas
  - Hazardous areas
- Current Deed or Title Commitment (1 copy)
- Proof of Access (10 copies)
  - If property is not adjacent to a county maintained or dedicated road/right-of-way: A recorded access easement indicating that a minimum of 20 foot access wide easement exists over abutting private property

*Recommended:*

- Pre May 5, 1972 Deed (1 copy)
- Proof of Water (10 Copies)
  - One of following: written statement from water district verifying that necessary taps are available, well permit, or court approved plan for water augmentation
- Proof of Sewer (10 copies)
  - Either a written statement from appropriate sanitation district verifying that all necessary taps are available or a written statement from Jefferson County Health and Environment indicating the viability of obtaining individual septic permits
- Proof of Fire Protection (10 copies)
  - Written statement from appropriate fire district indicating that they serve property
- Written Restrictions (10 copies)
- Landscape Plan (10 copies)
  - Preliminary plan showing locations of landscaping and general type of materials expected to be used in each area

**Site Approval Process (30 days)**. The Jefferson County Site Approval Process is for public or semi-public agencies wishing to construct a public facility that does not comply with zoning for that property. Prior to site approval, a case manager is assigned and will evaluate that all required documentation is submitted. The case manager assists through the formal application process. All individual property owners within 500 feet of the property must be notified during the application process (the county provides the forms). The case manager then refers the application/documentation to county divisions, government agencies and registered associations. The case manager collects all comments from the referral process and provides them with recommendations to the applicant. The applicant will then make revisions and resubmit affected documents prior to the planning commission public hearing. Signs must be posted on the property at least 14 days prior to a public hearing and location of property dictates quantity and location of signs. The Planning Commission reviews the site approval at a public hearing and will either approve, conditionally approve or reject the request.

*Requirements:*

- Application Form and Cover Letter with brief description of proposal
- Legal Description of property
- Proof of Ownership
  - Copy of current deed or title commitment for property
- Mineral Estate Notification Form
  - Verifies applicants legal obligation to contact owners of any mineral rights on property
- Vicinity Map that shows directional location of property
- Boundary Survey (required in cases where land cannot be properly mapped)
- Written Restrictions
  - Establish specific regulations for the property
- Community Notification Forms
  - Completed notification forms, addressed to surrounding property owners and stamped with envelopes using County's return address
- Phase I Drainage Report (required in some cases)
  - Required when property contains major drainage way that will be modified
- Proof of Access
  - If property is not adjacent to a public road, applicant must provide access easement or documentation that one can be obtained
- Proof of Water
- Proof of Fire Protection
  - Written statement from the appropriate fire district indicating service to property

*Recommended:*

- Traffic Study
  - development resulting in more than 1000 vehicles per day
- Geologic Report
  - For properties located in the designated dipping bedrock overlay zone
- Conceptual Site Plan
  - To include parking, landscaping, and other features

The format for submittal is illustrated in Figure 4-6.

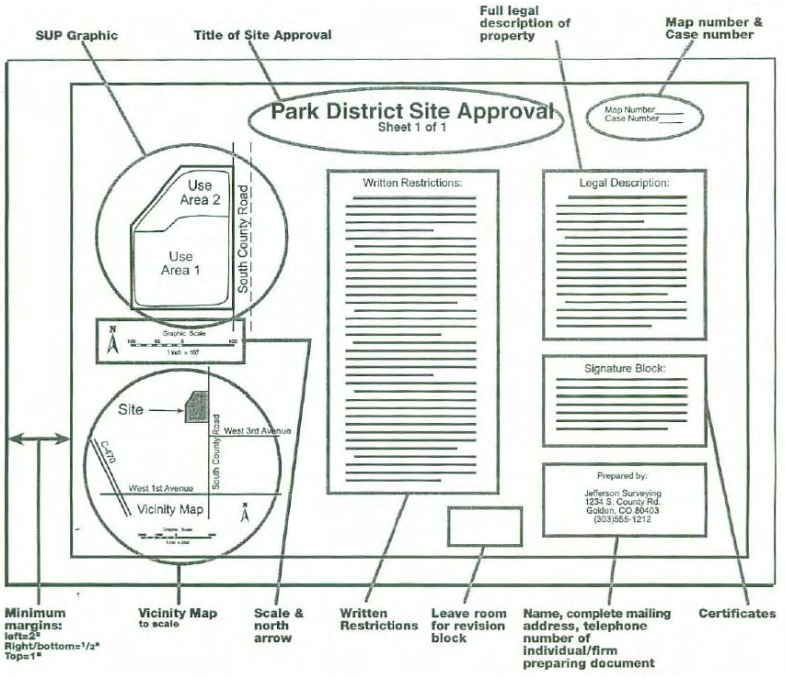



**Figure 4-6. Site Approval Format (Submitted in 24" x 36")**

**Site Development Plan Process** (less than 90 days). This is an administrative process designed to provide an objective evaluation procedure. This process must be completed before any building permits are issued. Two application packages including all forms, fees and supporting documentation must be provided. A development coordinator reviews the application package for completeness. The application may be referred to other county departments and outside agencies. The development coordinator will collect all comments from the referral process should it occur and relay them to the applicant. The applicant must then address in writing all issues and deficiencies identified by referral agencies. A case manager assesses the final submittal and prepares a memorandum for review and decision by the zoning administration. After a site development plan is approved, the applicant must submit a mylar of the site plan within 30 days.

*Requirements:*

- Application Form and Fees
- Plans
  - To scale (1" = 50' or greater) in format specified by zoning resolution
  - Include site plan, landscape plan, architectural evaluations, grading and erosion control plan, drainage plan/phase III drainage report, civil construction plans, lighting and parking plans
- Supporting Documents
- Proof of Ownership
  - copy of current deed and title insurance commitment
- Proof of water and sewer

- Proof of Access
- Fire Protection
    - if not in fire district (landfill area is not in a fire district) must provide a contract with a district indicating they will provide service
- Survey
- Geotechnical Report
    - a design level report with recommendations for foundation design, floor slab, pavement design and site grading
- Floodplain Overlay Zone District Report
    - Required if modification to floodplain are proposed
- Deeds
    - Submit any deeds for dedications of rights-of-way or easements
- Performance Guarantees
    - Exhibits for public improvements and landscaping work as required by Land Development Regulation
- Evidence of a minimum one year warranty for all plant materials prior to release of landscape guarantee

The Site Development Plan format is available Figure 4-7. The plan must be in this format for submittal to Jefferson County.

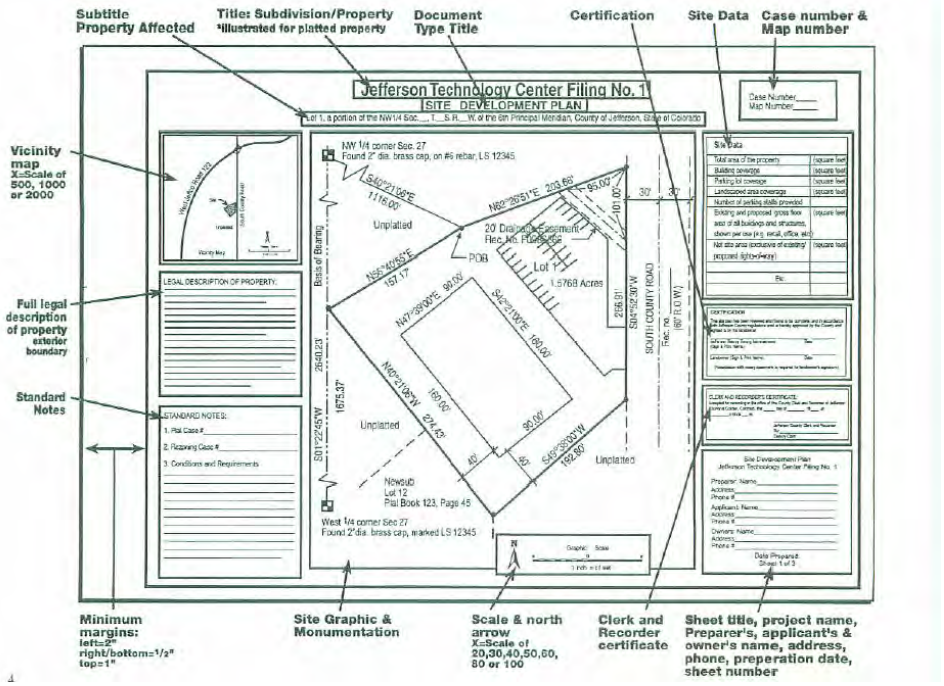



**Figure 4-7: Site Development Plan Format (Submitted in 24" x 36")**

**Building Permit** (7 to 10 days). After the above processes are complete, building, well and other building permits can be obtained. Building permits are typically issued in 7-10 business days. All told the entire building permit process (provided all information needs and requirements are met) can take approximately 130 business days, or approximately five to six calendar months.

# 5 FUEL SUPPLY CONTRACTS

The key elements of a supply contract include fuel moisture content, physical form, quantity, price, quality, term and delivery/transportation terms. Appendix C contains a sample long-form contract for the procurement of wood biomass fuel. Appendix D provides a short-term agreement for wood fuel procurement from smaller suppliers. The following subsections describe the key components of each and how they are integral to an overall fuel supply management system.

## *5.1 Long-form Supply Contract*

This type of supply agreement is suggested for a multi-year contract with a major supplier of biomass fuel (i.e., more than 2,000 wet tons per year as a suggested size limit). Appendix C provides sample language for such an agreement. The language from this document draws heavily from a prior report prepared by the U.S. Department of Energy's Southeastern Regional Biomass Energy Program,[18] supplemented with clauses from other currently operating biomass power generating stations. This document is intentionally generic with respect to specific legal requirements that might affect specific geographic areas, but includes some overall features that are advisable for any biomass fuel procurement contract. Some highlights of the contract language and discussion of some possible variations are described below.

Paragraph 2 defines fuel specifications for the suppliers, which are spelled out in Attachment A. The fuel specifications should require that fuel supplies be free of dirt, metal, stones and other contaminants, with the understanding that some proportion of these materials is unavoidable and must be mitigated using screens, shakers magnets and metal detectors at the plant. The values for moisture content, particle size, ash content and particle size distribution are specific to particular technologies: the values in this sample contract are compatible with thin-pile spreader-stoker technology. The fuel specifications in Appendix A are written assuming that fuel particle size distribution will be tested by sampling truckloads from suppliers and running them through screens to test the particle size distribution over time. This is a common practice and can help identify the source of materials with an unacceptable level of over- or under-size particles. However, it may not be the most efficient or effective method to gauge whether the fuel supply entering the combustion or gasification chamber actually does meet the appropriate fuel particle size distribution. Conveyor-belt image analysis systems for instance can help classify fuel particle distribution as it is conveyed into the combustion or gasification chamber, and could be a good complement to sampling individual loads for compliance with fuel specifications.

Paragraph 3 of the contract specifies the measurement units for the fuel. Most wood biomass fuel is received wet and many suppliers speak in terms of wet tons or volume measurements and do not closely monitor moisture content. However, using bone dry tons as units of measurement does have the advantage of more easily comparing wood fuels of similar species on the basis of energy content and can aid in development of a more consistent pricing policy that rewards suppliers for providing fuel with lower moisture content, which aids in thermal efficiency for biomass boilers. One compromise between the two units is to use wet tons as the basis for

[18] Tennessee Valley Authority Renewables and Special Projects, Biomass Design Manual Industrial Size Systems, Reprint 1991.

contracts, but to measure moisture content and create a price incentive for suppliers that provide fuel with a lower moisture content. Measuring moisture content per truckload can be accomplished via a number of methods including the use of an automated truck sampling system at the truck scaling location. To the extent practicable the contract should specify the means of fuel moisture content, Btu value and other measurements to avoid conflicts.

Paragraph 4 discusses transportation scheduling, delivery and receiving. More specific contract language than provided here should relate to access control for the site. This language could not be developed prior to the design and layout of access and on-site storage systems for a wood fuel boiler. Items to be further clarified include the type of truck trailer required, exact street location of entrance, hours for accepting fuel and specific conduct required for seller to comply with all existing regulations and respect community concerns related to truck traffic.

Contract language here assumes that the supplier bears the responsibility for transportation costs. In the event that any biomass subsidies become available to contractors that process and transport biomass, transportation costs should be borne by the seller if the seller wants to take advantage of those subsidies. If however, those subsidies are designed to reimburse the end user for transportation costs, the buyer may want to pay those costs if they believe the subsidy is sufficient to cover trucking costs charged by the seller.

Paragraph 6 discusses pricing options. In this case we used a simple pricing strategy with a fixed price per ton for a five year period, with a significant penalty for fuel that does not meet fuel specifications. Pricing can be done on a wet ton or dry ton basis. In either case, fuel moisture content sampling is recommended so that the fuel energy content, and hence energy input to the boiler system is a known quantity. Other strategies can include a price index with a price escalation factor to account for changing market prices for wood fuel and incentives for providing fuel with lower moisture content.

Using a price index involves setting an initial price for fuel and then periodically adjusting the price by a factor that can take into account a variety of factors, including price trends or other market factors. Using such a price index can provide a price incentive for fuel suppliers in times of higher overall energy costs by tying the biomass fuel price to power, natural gas or heating oil costs. In such a case, the fuel price in a given month would be equal to the greater of the initial price in the contract or the calculated index price. The index price would be calculated by multiplying the initial price by a price adjustment factor. One example of such a price adjustment factor is the quotient of a 12-month rolling hourly wholesale price for power, natural gas or heating oil divided by the base index price. The base index price would be hourly average wholesale power, natural gas or heating oil prices for 12-month period preceding the month prior to the beginning of the fuel supply contract.

Using incentives such as a price escalator to encourage suppliers to reduce moisture content can improve combustion efficiency (thereby reducing fuel use), reduce opacity of emissions and reduce ash generation. Developing a price incentive to offer to fuel sellers depends on the value that these improvements offer the facility. Quantifiable benefits to estimate include reductions in fuel costs due to improvements in combustion efficiency gained through the use of lower moisture content fuels and reduced ash disposal costs. Backing out the fuel cost savings requires an understanding of the Btu content of the fuels for each load and how it affects overall fuel moisture content of the plant fuel supply. For every percent reduction in moisture content in the fuel supply, the plant can estimate the difference in plant thermal efficiency, and therefore the

reduction in the Btu input needed to achieve the same plant output. The fuel demand reduction can be calculated from this value, and a corresponding value placed on fuel with a lower moisture content. A similar method can be used to calculate ash disposal savings.

Another means by which to provide an incentive for fuel suppliers is to develop a pricing system based on the Btu content per ton of fuel sold. Automatic probe sampling of each truckload can assist in estimation and tracking of fuel Btu content for application of a fuel pricing strategy that would provide an incentive for higher quality fuels.

The plant will have to develop its own schedule for paying fuel suppliers that will be compatible with both its own cash flow patterns and those of the fuel suppliers.

## *5.2 Short-form Supply Contract*

Appendix D provides an example of a short-form supply contract that can be used for smaller suppliers (e.g., fewer than 2,000 green tons of fuel per year, or another amount acceptable to the facility that can be replaced within several months time). The general information supplied is similar to that in the long-form contract, but the specifications are not as stringent, based on the presumption that such suppliers would comprise a small proportion of the overall fuel supply and that smaller suppliers may have less processing capabilities.

# 6 TECHNICAL AND ECONOMIC COMPARISON OF NATURAL GAS, WOOD CHIPS AND PELLETS

In this section we briefly evaluate two technologies for heating the Jefferson County Jail with biomass compared with the existing natural gas-fired equipment. One technology uses wood chips as a fuel and the other uses wood pellets. Wood pellets are manufactured from wood by-products to have a consistent size, shape, moisture content and ash content. The wood chips are minimally processed to a specified size range (matchbook size), and usually have higher moisture content and lower bulk density than wood pellets. Because of these differences, the chip system requires a larger fuel storage volume than does a pellet system, and has higher electricity and maintenance requirements. By contrast, the pellet system has a higher fuel cost because of the processing.

Table 6-1 shows the design parameters for heating the Jefferson County Jail with biomass. The peak load is estimated at 9.7 million Btu per hour (MMBtu/hr). The biomass systems are each sized at 10 MMBtu/hr output to meet the peak load.

**Table 6-1. Design parameters**

| Parameters | Value | Unit |
|---|---|---|
| Peak Load | 9.7 | MMBtu/hr |
| System size | 10 | MMBtu/hr |
| Assumed chip MC | 50% | percent |
| Peak 7 day load | 1142 | MMBtu |
| Annual load | 36,493 | MMBtu |

Table 6-1 also shows the peak 7 day heating load at the jail is 1,142 million Btu. This value is used to estimate the quantity of chips or pellets required to be stored on-site.

Table 6-2 shows details of a chip-fired heating system and a pellet-fired heating system each designed to meet the heating load at the jail. Due to the higher moisture content of wood chips, they have a significantly lower energy density than pellets.

Costs listed in Table 6-2 are not firm quotes, but are estimates based on prior experience of the authors. The pellet system has the advantage of lower capital costs, lower maintenance requirements and lower estimate electrical cost.

**Table 6-2. Comparison of Chip and Pellet heating systems**

| Parameter | Chip system | Pellet system | Unit |
|---|---|---|---|
| System size | 10 | 10 | MMBtu/hr |
| Peak input requirement | 16.7 | 10.8 | MMBtu/hr |
| Peak fuel requirement | 1.9 | 0.7 | ton/hr |
| Peak 7-day fuel requirement | 128 | 70 | ton |
| Annual fuel use | 7,070 | 2,472 | ton/year |
| Fuel cost (as delivered) | $30 to 40 | $120 to 147 | $/ton |
| Fuel cost (gross heating value) | $3.37 | $8.96 | $/MMBtu input |
| Fuel cost (delivered to space)[19] | $5.81 | $9.96 | $/MMBtu output |
| Annual fuel cost | $212,086 | $363,447 | $/year |
| O&M cost | $10,510 | $2,628 | $/year |
| Electrical cost | $13,140 | $6,570 | $/year |
| Total annual cost | $235,736 | $372,644 | $/year |
| Total capital cost | $750,000 | $500,000 | 2006$ |

At a price of $30 per green ton for wood chips and $147/ton for pellets, wood chips are the less expensive option, which results in significant annual savings. The reduced annual operating costs will cover the increased capital cost in just under two years. This is commonly referred to as the simple payback period.

Table 6-3 shows the economic benefit of installing a wood chip heating system versus a pellet fuel heating system at the Jefferson County Jail at the prices shown. Due to the high cost of pellets, the chip system is a better economic option.

**Table 6-3 Economic analysis of Chip vs Pellet heating systems at the Jail based on chip cost of $30/ton and pellet cost of $147/ton**

| | |
|---|---|
| **Simple Payback Period (Years)** | 1.9 |
| **30-Year total of Savings [$]** | $ 9,817,996 |
| **Total of savings/capital costs** | 37.0 |
| **30-year APR Equivalent** | 12.80% |

| | |
|---|---|
| **NPV Chip vs Pellet System - 30-year [$]** | $ 3,937,735 |
| **IRR - 30-year** | 59.4% |

Table 6-4 shows the price points for pellets and wood chips at which total annual costs are equal. For example, at a pellet cost of $120/ton, the annual costs for the chip system will be lower for any chip price below $40/green ton, otherwise the pellet system will have lower annual costs.

**Table 6-4 Price points with equal total annual costs [$/ton delivered]**

| Pellet cost | Chip cost |
|---|---|
| $120 | $40 |
| $150 | $50 |

[19] This refers to the cost of thermal energy supplied to the space, and reflects losses due to system inefficiency. The pellet system has higher efficiency, so the cost increase is not as great as with the chip system.

Just as we have compared the two biomass systems, it is important to compare the biomass systems with the existing natural gas system. A life cycle cost analysis was performed on the jail using the Federal Energy Management Program guidelines (see Table 6-5). Over a twenty-year horizon, a pellet system is more expensive to own and operate than an equivalently sized chip system but it will likely require less maintenance from facility staff and have cleaner emissions. Both systems are less expensive than natural gas on a life cycle cost basis. The operating success of either system is dependent upon well-defined fuel supply contracts as well as training and support for maintenance staff responsible for facility operation. The economic analysis is sensitive to the price of biomass fuel and natural gas prices.

**Table 6-5. Comparative Life Cycle Costs for Three Heating Systems at the Jefferson County Jail**

| Alternative | Initial Cost | Life Cycle Cost |
|---|---|---|
| Natural Gas | $ - | $ 4,087,350 |
| Biomass Pellets | $ 500,000 | $ 3,847,544 |
| Biomass Chips | $ 765,000 | $ 2,455,844 |

# 7 ECONOMIC ANALYSIS

This section encompasses an economic analysis from two perspectives for the three different development options. The first perspective addresses economic development issues such as the level of capital expenditures and job creation. The second approach provides an analysis of the financial returns that may be possible with certain business ventures under defined conditions. The overall intent of this chapter is to provide decision-makers with information regarding the value of the biomass development in Jefferson County.

## *7.1 Potential Economic Development*

For the three different development options we have calculated values for important economic development parameters as shown in Table 7-1. The central heating facility, conceptually designed to process chips for delivery to a large user at Zuni, is the least expensive installation. The small pellet mill, approximately 5 tons per hour output, is estimated to cost about $5.6 million, installed. The bioethanol plant is hypothetical only in that no plants have ever been constructed on a commercial basis. We have purposefully incorporated conservative (i.e., high) capital costs to allow for unexpected occurrences. The high capital costs are further increased by a 15% contingency factor.[20]

**Table 7-1. Estimated Direct Economic Impacts Associated with Biomass Development in Jefferson County**

| Category | Central heating | Pellet plant (small) | Bioethanol plant |
|---|---|---|---|
| Resource Output (bdt/yr.) | 129,046 | 45,870 | 4,600,000 |
| Daily Truck Deliveries | 20-40 | 10-12 | 13-17 |
| Capital Investment | $3,776,557 | $5,600,000 | $25,000,000 |
| Employment, # of people | | | |
| Construction | 50 | 30 | 30 |
| Operation | 21 | 15 | 15 |

## *7.2 Financial Analysis of Three Biomass Facilities*

We utilize a twenty-year discounted cash flow (DCF) methodology to assess the economic feasibility of the three project options from the point of view of a private firm developing, constructing, owning and operating the project.[21] The annual cash flow approach allows for the

[20] There is a subtle difference between the capital costs shown in section 7.1 and the capital costs in section 4. Capital costs in section 7.1 are representative of a complete facility whereas in section 4 the capital costs are only for the fuel processing portion of the facility. Thus the capital cost values in section 7 are higher than in section 4. For the pellet facility we have added in section 7 costs for a dryer and the actual pellet mill. For the bioethanol facility we have added costs for the engineered equipment including the gasifier, alcohol skid, compressor station and assorted ethanol handling equipment.

[21] For the chips to ethanol facility we use a ten-year horizon because of the risk involved with the project. A commercial plant has not been built at this writing and thus there are considerable uncertainties about the capital and operating costs.

visualization of differing assumptions and inputs over time. The pro forma model includes an income statement, balance sheet and resulting cash flows. Inputs to the model include the technical analysis of plant performance plus associated financial assumptions. The output of the model includes the calculated levelized cost of production as well as additional measures of economic performance including net present value and debt service coverage ratios.

The intent of the analysis is to provide a sense of the profitability of the three biomass ventures. The analysis should not be considered definitive as we have not conferred with private project developers regarding important financial inputs. Rather the results are illustrative of the relative profitability of the three ventures with varying degrees of risk.

## *7.3 Finance Assumptions*

A range of financial / economic inputs are necessary to account for economic conditions in the market place. The elements of Table 7-2 that have the greatest influence on the cash flow results are the interest rate / discount rate, the inflation rate, debt coverage service ratio requirement, and the electricity selling price. The interest rate reflects current rates for commercial loans (We assume 40% equity investment in the project, a debt-equity ratio that is representative of current market conditions.). The discount rate, used in the Net Present Value (NPV) calculation, represents a value for a developer that reflects a risk free investment. The projected inflation rate is derived from monthly long-term forecasts from the US Federal Reserve Board. The debt coverage ratio is a blended figure that McNeil personnel have observed as terms provided by a variety of lenders. It is certain the actual ratio for any given developer will vary, possibly even to a higher level.

**Table 7-2. Finance / Economic Inputs to Pro Forma Model**

| Category | Units | Value |
|---|---|---|
| Income Tax Rate | % | 44 |
| Electricity Escalation Rate | % | 0 |
| General Inflation/Escalation Rate | % | 2.8 |
| Loan Interest | % | 7.5 |
| Discount Rate | % | 10 |
| Equity | % | 30 |
| Depreciation Method | | MACRS |
| Loan Repayment Term | years | 20 |
| Project Life | years | 25 |
| Salvage Value | % | 5 |
| Annual Plant Insurance | $/year | 15,000 |
| Loan issuance fee | % | 0.01 |

## *7.4 Capital and Operating Costs*

Estimated installed capital costs for the three options are shown in Table 7-3. The least expensive is the fuel processing facility, approximately $3.8 million followed by the small pellet mill at

$5.6 million. The bioethanol facility is the most expensive, about $25 million. Annual fixed operating costs rang from about $2-5.8 million per year while annual variable costs range from $4.8 to 8.9 million. Total operating costs vary from $7.2 to about $11 million per year.[22]

**Table 7-3. Estimated Capital and Operating Costs for Biomass Development Options**

| Category | Units | Central heating | Pellet plant (small) | Bioethanol plant |
|---|---|---|---|---|
| Capital Cost | $ | $ 3,800,000 | $ 5,600,000 | $25,000,000 |
| Operating Costs (yr. 3) | | | | |
| Fixed* | $/yr. | $ 2,100,000 | $ 2,200,000 | $ 5,800,000 |
| Variable** | $/yr. | $ 8,900,000 | $ 5,000,000 | $ 4,800,000 |
| Total | $/yr. | $11,000,000 | $ 7,200,000 | $10,600,000 |

* Fixed costs include labor, finance and depreciation expenses

** Variable costs include fuel at $60/bdt

## *7.5 Financial Analysis*

The financial analysis is constrained in several ways. First, we are not aware of any firm plans for development f any of the selected facilities by a private firm. Thus we can only speculate on certain input variables that have influence on the various measures of financial performance. Similarly, we have selected metrics for financial performance which may or may not be representative of what other firms may use as indices of profitability. While we have selected conservative input values, it is possible our analysis will illustrative only for any future developers. Further, we are not attempting to select the "best" project for the potential sites. Rather, our intent is to assess baseline conditions that would allow for successful project development. Our economic analysis focuses on determining plausible supply and demand values that result in positive economic forecasts.

For comparative purposes we focused the financial analysis on the biomass purchase price that would allow for a positive net present value (NPV) of at least $5 million over the time horizon. We selected a sufficiently high NPV value to allow for significant changes in input values without adverse effects on the "go / no-go" investment decision. As shown in Table 7-4, the biomass purchase prices that meet the established criteria range from $62-80 / bdt. Thus for a chip processing facility selling chips to another user (e.g., Zuni), the purchase price for chips should not exceed about $62/bdt. It is clear that facilities that both process chips and subsequently manufacture another product (either pellets or ethanol) have the opportunity to pay a higher price for raw material.

[22] Operating costs reflect costs from year 3 when the plant is expected to be in full operation. Certain labor costs and other expenses are not incurred in the early years of operation as the facility experiences shakedown periods and the crew is learning how to run the plant.

**Table 7-4. Required Biomass Purchase Price for $5 Million Net Present Value at Established Selling Prices**

| Category | Units | Central heating | Pellet plant (small) | Bioethanol plant |
|---|---|---|---|---|
| Biomass purchase price | $/bdt | $ 62.00 | $ 80.00 | $ 74.00 |
| Product selling price | $/bdt or $/gallon | $ 85.00 | $ 140.00 | $ 2.00 |

There is a competitive market for both pellets and ethanol in the Denver area and the selling prices in Table 7-4 reflect current conditions. It can be argued that the pellet selling price is low but we have not assumed mark-up costs for marketing. However, for the biomass chips the selling price may be too high. At $85/dry ton, chips are about $4.70/MMBtu. Coal, another solid fuel, is delivered within Colorado for less than half that cost. Natural gas is more expensive, perhaps $7.00-8.50/MMBtu. While the price volatility and supply constraints that have been exhibited in the natural gas market have made users look for alternative fuels, biomass energy must be cost-competitive with established fuels in order to foster market adoption.

# 8 SUMMARY OF KEY FINDINGS

This section briefly summarizes some of the key findings of this technical report, by subject area.

**Biomass resource availability.** We estimated that approximately 65,000 tons of clean wood waste could be obtained reliably each year from clean construction waste, urban tree residues and wood products manufacturers within an approximate 60 mile radius of Golden, Colorado. A proposed USFS stewardship contract that will likely be released for bid in the fall of 2006 is planned to fund 5,000 acres of treatment each year for 10 years. Projected biomass yields range from 4 to 10 tons per acre. Based on this yield, biomass generation from the stewardship contract would be 20,000 to 50,000 tons per year. There is no guarantee that biomass removal will be required on all acres treated. To account for this uncertainty, we assumed that 50 percent of the total biomass generated will be available for a biomass facility, or 10,000 to 25,000 tons per year. Combining urban and forest sources, we estimate conservatively that 75,000 to 90,000 tons of material per year would be available for a biomass facility. If the size of the stewardship contract were increased to 10,000 acres per year, within the desired annual treatment level for the PSICC and AR National Forests, this availability could increase to 85,000 to 115,000 tons per year. This is sufficient material to supply a pellet mill or the district heating and cooling portion of energy production at the Zuni Plant, but not sufficient to meet additional needs for power production or the entire steam requirements of the Denver district heating system.

**Biomass supply systems.** This study evaluated the equipment and other requirements for a chip plant to supply (from smallest to largest) a pellet plant that would produce 30,000 tons of pellets per year, a 200 wet ton per day bioethanol plant, and a biomass-fired utility-scale district heating system (modeled after Xcel Energy's Zuni Plant). A pellet plant producing 30,000 tons of pellets each year would require approximately 57,000 tons of wood feedstock each year. A 200 dry ton per day biomass ethanol facility would need approximately 120,000 tons of material per year, assuming 45 percent wood moisture content. To meet steam used for heating and cooling for the Denver district heating system by the Zuni plant, the approximately 50,000 tons of fuel would be needed. To meet this need plus producing power 20 percent of the time, the plant would need 260,000 tons of fuel per year. A similar quantity would be required if the Zuni plant were to meet all of the steam needs for the district heating system.

A preliminary estimate of the size of the site required to support such a facility ranges from 5 to 15 acres (with little room for facility expansion). The final size of the site would depend on detailed engineering design for the facility. Typical system components include wood fuel receiving, truck scales, a fuel hopper, conveyors to load chips into regrind and screens, log storage, chip storage (open pile, partially below-ground bunker or silo are common storage types) and conveyor/chip reclaim equipment. If a pellet mill or ethanol plant were collocated with the facility, additional equipment would be needed and the overall facility size would be closer to the high end of the size range.

**Siting/permitting biomass facility.** There are no insurmountable siting/permitting obstacles for a biomass facility at either of the two top sites being considered, parcels adjacent to the former Rooney Road landfill or Jefferson Research Center I located on Highway 72 in Arvada. There are pros and cons to each site.

*Rooney Road Landfill site.* The former Rooney Road Landfill site is centrally located and has ready access to major regional highways. Agricultural parcels would have to be rezoned and

there are possible viewshed issues that could result in public opposition because of its proximity to I-70, I-470, Green Mountain and Lookout Mountain. These could be overcome through advantageous use of grading, site design/orientation and public outreach. The former Rooney Road landfill site would require crossing an Xcel Energy right-of-way, but this will require careful grading and site design as part of a licensing agreement or easement to obtain access to the site. There is no known water source at this location, which will require water storage (if well water cannot be identified and used) for fire suppression, process and employee needs. This location would not be suitable for ethanol production because of the lack of water; the lack of water issue would likely not be an issue for a pellet plant or stand-alone chip plant.

*Jefferson Research Center I.* This site is located farther away from many urban wood residue generators. As a result it might be more difficult to attract suppliers to this location, and costs could be higher for transportation and fuel procurement. However, there is room for expansion and the viewshed issues are not as significant as Rooney Road Landfill, since a large portion of the industrial center is not visible from the highway or surrounding parcels. There are similar wood processing and materials handling facilities in the area (A1 Organics, Pioneer) and a BFI landfill which could be a source of material. There is rail access and the site is zoned industrial, which means there would be no need for a public rezoning process. However, there are potential site contamination issues due to past uses that could increase development costs to an unknown extent due to remediation needs. There is a lot of aging industrial infrastructure on the site, some of which could be required to be dismantled prior to reuse. Determining what the contamination issues could be was beyond the scope of this study and there is no public data available on this issue.

**Jefferson County Jail:** Our analysis suggests that biomass is the least expensive fuel source for heating the jail. Biomass chips and a new boiler to supplement the existing natural gas boiler are the least cost alternative. Jefferson County can exhibit leadership in utilization of renewable energy by implementing a biomass heating system at the jail. There is a similar system in Boulder County that can be used as an example.

**Capital and operating costs**. Table 8-1 includes estimated capital and operating costs for a wood fuel processing facility for each of the three facility types.

**Table 8-1 Summary of Capital and Operating Costs**

| Category | Units | Central heating | Pellet plant (small) | Bioethanol plant |
|---|---|---|---|---|
| Capital Cost | $ | $ 3,800,000 | $ 5,600,000 | $25,000,000 |
| Operating Costs (yr. 3) | | | | |
| Fixed* | $/yr. | $ 2,100,000 | $ 2,200,000 | $ 5,800,000 |
| Variable** | $/yr. | $ 8,900,000 | $ 5,000,000 | $ 4,800,000 |
| Total | $/yr. | $11,000,000 | $ 7,200,000 | $10,600,000 |

* Fixed costs include labor, finance and depreciation expenses

** Variable costs include fuel at $60/bdt

Capital and operating costs are budgetary estimates. Capital cost estimates include project development, engineering, equipment construction and other miscellaneous costs. Capital cost estimates include a 15 percent contingency value to account for variance in budget items. Operating costs include estimated land lease, labor, taxes, spare parts, raw material, travel, G&A, utility and other miscellaneous expenses.

**Financial analysis of chip processing facility**. The financial analysis evaluated the net present value for a chip plant that would support a biomass district heating plant, a pellet operation and a cellulosic ethanol plant. The results also included an estimate of the break-even fuel price such a facility would have to pay for fuel to be economically viable and how that price varied with the selling price for the end product, whether that product is wood chips, pellets or ethanol. The required purchase price varies by operation and ranges from $62-80/bdt.

**Table 8-2. Required Biomass Purchase Price for $5 Million Net Present Value at Established Selling Prices**

| Category | Units | Central heating | Pellet plant (small) | Bioethanol plant |
|---|---|---|---|---|
| Biomass purchase price | $/bdt | $ 62.00 | $ 80.00 | $ 74.00 |
| Product selling price | $/bdt or $/gallon | $ 85.00 | $ 140.00 | $ 2.00 |

The economic analysis for a chip plant sized to meet power production (20 percent of time) and district heating and cooling needs supplied by the Zuni Plant assumes that the plant will require 260,000 tons of wood fuel each year. A conservative analysis of the biomass resource suggests that this will be a difficult goal to achieve. Therefore, the results of the analysis of a facility at this scale are hypothetical, but do show the economies of scale that can help a larger facility become economically viable with higher raw material costs and lower product prices than a smaller facility.

One possible means to improve the economics of wood processing is to add capacity to an existing facility, since there are several existing wood recycling and waste handling facilities in the region. It was beyond the scope of this study to evaluate the economics of this opportunity, but it is an option that should be considered.

# Appendix A. Capital and O&M Cost Estimate Detail

## Estimated Project Costs

| Category | Central Heating | | | | Pellet Plant | | | | Bioethanol | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unit | Quantity | Rate ($/unit) | Cost ($) | Unit | Quantity | Rate ($/unit) | Cost ($) | Unit | Quantity | Rate ($/unit) | Cost ($) |
| **DEVELOPMENT** | | | | | | | | | | | | |
| Contracts and negotiations | p-h | 80 | 200 | 16,000 | p-h | 80 | 200 | 16,000 | p-h | 80 | 200 | 16,000 |
| Permits and appeals | p-h | 160 | 80 | 12,800 | p-h | 160 | 80 | 12,800 | p-h | 160 | 80 | 12,800 |
| Project financing | p-h | 120 | 100 | 12,000 | p-h | 120 | 100 | 12,000 | p-h | 120 | 100 | 12,000 |
| Project management | p-h | 600 | 100 | 60,000 | p-h | 400 | 100 | 40,000 | p-h | 600 | 100 | 60,000 |
| Travel & accomodation | p-trip | 30 | 400 | 12,000 | p-trip | 10 | 400 | 4,000 | p-trip | 30 | 400 | 12,000 |
| Construction permits | p-h | 160 | 80 | 12,800 | p-h | 120 | 80 | 9,600 | p-h | 160 | 80 | 12,800 |
| Environmental permits | p-h | 160 | 80 | 12,800 | p-h | 120 | 80 | 9,600 | p-h | 160 | 80 | 12,800 |
| Legal | p-h | 200 | 200 | 40,000 | p-h | 200 | 200 | 40,000 | p-h | 200 | 200 | 40,000 |
| Construction consultants | p-h | 400 | 120 | 48,000 | p-h | 200 | 120 | 24,000 | p-h | 400 | 120 | 48,000 |
| Public relations | p-h | 100 | 120 | 12,000 | p-h | 100 | 120 | 12,000 | p-h | 100 | 120 | 12,000 |
| Other | Cost | 250 | 100 | 25,000 | Cost | 250 | 100 | 25,000 | Cost | 250 | 100 | 25,000 |
| **Subtotal** | | | | **263,400** | | | | **205,000** | | | | **263,400** |
| **ENGINEERING** | | | | | | | | | | | | |
| Site and building design | p-h | 400 | 80 | 32,000 | p-h | 400 | 80 | 32,000 | p-h | 400 | 80 | 32,000 |
| Construction supervision | p-h | 1500 | 60 | 90,000 | p-h | 800 | 60 | 48,000 | p-h | 1500 | 60 | 90,000 |
| Startup and testing | p-h | 100 | 60 | 6,000 | p-h | 100 | 60 | 6,000 | p-h | 100 | 60 | 6,000 |
| **Subtotal** | | | | **128,000** | | | | **86,000** | | | | **128,000** |
| **EQUIPMENT** | | | | | | | | | | | | |
| Truck scales/receiving | EACH | 1 | 110,000 | 110,000 | EACH | 1 | 110,000 | 110,000 | EACH | 1 | 110,000 | 110,000 |
| Unloading (truck dump) | EACH | 2 | 300,000 | 600,000 | EACH | 2 | 125,000 | 250,000 | EACH | 2 | 125,000 | 250,000 |
| Drag chain feeder | EACH | 1 | 20,000 | 20,000 | EACH | - | 20,000 | - | EACH | - | 20,000 | - |
| Conveyor | EACH | 1 | 50,000 | 50,000 | EACH | 1 | 50,000 | 50,000 | EACH | 1 | 50,000 | 50,000 |
| Screens/magnets | EACH | 1 | 100,000 | 100,000 | EACH | 1 | 40,000 | 40,000 | EACH | 1 | 100,000 | 100,000 |
| Hammer hog | EACH | 2 | 150,000 | 300,000 | EACH | 1 | 50,000 | 50,000 | EACH | 1 | 150,000 | 150,000 |
| Conveyor - for regrinds | EACH | 1 | 25,000 | 25,000 | EACH | 1 | 25,000 | 25,000 | EACH | 1 | 25,000 | 25,000 |
| Drag chain reclaim | EACH | 1 | 25,000 | 25,000 | EACH | 1 | 25,000 | 25,000 | EACH | 1 | 25,000 | 25,000 |
| Conveyor -reclaim | EACH | 1 | 50,000 | 50,000 | EACH | 1 | 50,000 | 50,000 | EACH | 1 | 50,000 | 50,000 |
| Front end loaders (9 cubic meter bucket) | EACH | 1 | 230,000 | 230,000 | EACH | 1 | 230,000 | 230,000 | EACH | 1 | 230,000 | 230,000 |
| Truck tractors | EACH | 3 | 75,000 | 225,000 | EACH | 1 | 75,000 | 75,000 | EACH | 3 | 75,000 | 225,000 |
| Truck trailers | EACH | 3 | 25,000 | 75,000 | EACH | 1 | 25,000 | 25,000 | EACH | 3 | 25,000 | 75,000 |
| Building | $/SF | - | 10 | - | $/SF | 12,763 | 10 | 127,628 | $/SF | - | 10 | - |
| Concrete bunker/foundation | $/SF | 49,131 | 4.45 | 218,631 | $/SF | 10,168 | 4.45 | 45,245 | $/SF | 43,548 | 4.45 | 193,787 |
| Miscellaneous | NA | NA | 150,000 | 150,000 | NA | NA | NA | 75,000 | NA | NA | 150,000 | 150,000 |
| **Subtotal** | | | | **2,178,631** | | | | **1,177,873** | | | | **1,633,787** |
| **BULK COMMODITIES AND CONSTRUCTION** | | | | | | | | | | | | |
| Piping | NA | NA | NA | 50,000 | NA | NA | NA | 50000 | NA | NA | NA | 50,000 |
| Electrical | NA | NA | NA | 50,000 | NA | NA | NA | 50000 | NA | NA | NA | 50,000 |
| Instrumentation | NA | NA | NA | 50,000 | NA | NA | NA | 50000 | NA | NA | NA | 50,000 |
| Landscaping | $/SF | 40000 | 2 | 80,000 | $/SF | 20000 | 2 | 40,000 | $/SF | 40000 | 2 | 80,000 |
| **Subtotal** | | | | **230,000** | | | | **190,000** | | | | **230,000** |
| **OTHER COSTS** | | | | | | | | | | | | |
| Shipping | NA | NA | NA | 25,000 | NA | NA | NA | 10,000 | NA | NA | NA | 25,000 |
| Spare parts | NA | NA | NA | 25,000 | NA | NA | NA | 25,000 | NA | NA | NA | 25,000 |
| G&A | NA | NA | NA | 108,932 | NA | NA | NA | 58,894 | NA | NA | NA | 81,689 |
| Training | NA | NA | NA | 10,000 | NA | NA | NA | 10,000 | NA | NA | NA | 10,000 |
| Performance/L&M bond | NA | NA | NA | 75,000 | NA | NA | NA | 75,000 | NA | NA | NA | 75,000 |
| WC & All Risk insurance | NA | NA | NA | 150,000 | NA | NA | NA | 100,000 | NA | NA | NA | 150,000 |
| Waste disposal | NA | NA | NA | 50,000 | NA | NA | NA | 50,000 | NA | NA | NA | 50,000 |
| Electricity | NA | NA | NA | 20,000 | NA | NA | NA | 20,000 | NA | NA | NA | 20,000 |
| Water/wastewater | NA | NA | NA | 20,000 | NA | NA | NA | 20,000 | NA | NA | NA | 20,000 |
| **Subtotal** | | | | **483,932** | | | | **368,894** | | | | **456,689** |
| **TOTAL - W/OUT CONTINGENCIES** | **$/year** | | | **3,283,963** | | | | **2,027,767** | | | | **2,711,876** |
| **CONTINGENCY VALUE** | **$/year** | | | **492,594** | | | | **304,165** | | | | **406,781** |
| **TOTAL PROJECT ESTIMATE** | **$/year** | | | **3,776,557** | | | | **2,331,932** | | | | **3,118,657** |

## Estimated O&M costs

| Annual Costs | Central Heating | | | | Pellet Plant | | | | Bioethanol | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unit | Quantity | Rate ($/unit) | Cost ($) | Unit | Quantity | Rate ($/unit) | Cost ($) | Unit | Quantity | Rate ($/unit) | Cost ($) |
| **PROPERTY TAXES** | $/year | NA | NA | **20,000** | $/year | NA | NA | **20,000** | $/year | NA | NA | **20,000** |
| **LAND LEASE** | $/acre-year | 10 | 20,000 | **200,000** | $/acre-year | 10 | 20,000 | **200,000** | $/acre-year | 10 | 20,000 | **200,000** |
| **INSURANCE** | $/year | NA | NA | **15,000** | $/year | NA | NA | **15,000** | $/year | NA | NA | **15,000** |
| **SPARE PARTS** | $/year | NA | NA | **150,000** | $/year | NA | NA | **150,000** | $/year | NA | NA | **150,000** |
| **RAW MATERIAL** | BDT | 129,046 | 60 | **7,742,772** | BDT | 31,536 | 60 | **1,892,160** | BDT | 65,700 | 60 | **3,942,000** |
| **LABOR** | | | | | | | | | | | | |
| Plant Manager | $/year | 1 | $ 137,058 | 137,058 | $/year | 1 | $ 137,058 | 137,058 | $/year | 1 | $ 137,058 | 137,058 |
| Deputy | $/year | 1 | $ 71,070 | 71,070 | $/year | 1 | $ 71,070 | 71,070 | $/year | 1 | $ 71,070 | 71,070 |
| Operators | $/year | 12 | $ 60,119 | 721,431 | $/year | 6 | $ 60,119 | 360,716 | $/year | 6 | $ 60,119 | 360,716 |
| Fuel Handling | $/year | 3 | $ 60,119 | 180,358 | $/year | 3 | $ 60,119 | 180,358 | $/year | 3 | $ 60,119 | 180,358 |
| Maintenance | $/year | 3 | $ 57,676 | 173,029 | $/year | 3 | $ 57,676 | 173,029 | $/year | 3 | $ 57,676 | 173,029 |
| Administration | $/year | 1 | $ 43,243 | 43,243 | $/year | 1 | $ 43,243 | 43,243 | $/year | 1 | $ 43,243 | 43,243 |
| **Subtotal** | | | | **1,326,190** | | | | **965,475** | | | | **965,475** |
| **TRAVEL AND ACCOMODATION** | $/trip | 40 | 400 | **16,000** | $/trip | 40 | 400 | **16,000** | $/trip | 40 | 400 | **16,000** |
| **GENERAL AND ADMINISTRATIVE** | $/hour | 500 | 100 | **50,000** | $/hour | 500 | 100 | **50,000** | $/hour | 500 | 100 | **50,000** |
| **UTILITIES** | | | | | | | | | | | | |
| Electricity | kWh | 5,429,468 | 0.07 | 380,063 | kWh | 3,213,327 | 0.07 | 224,933 | kWh | 3,989,782 | 0.07 | 279,285 |
| Natural gas | therm | 200 | 7.00 | 1,400 | therm | 200 | 7.00 | 1,400 | therm | 200 | 7.00 | 1,400 |
| Diesel | gal | 30,000 | 2.75 | 82,500 | gal | 15,000 | 2.75 | 41,250 | gal | 20,000 | 2.75 | 55,000 |
| Gasoline | gal | 1,000 | 2.75 | 2,750 | gal | 1,000 | 2.75 | 2,750 | gal | 1,000 | 2.75 | 2,750 |
| Water | gal | 557,000 | 0.00 | 1,365 | gal | 557,000 | 0.00 | 1,365 | gal | 557,000 | 0.00 | 1,365 |
| Wastewater treatment | gal | 543,500 | 0.00 | 1,631 | gal | 543,500 | 0.00 | 1,631 | gal | 543,500 | 0.00 | 1,631 |
| Waste disposal | cubic yards | 20,000 | 2.00 | 40,000 | cubic yards | 10,000 | 2.00 | 20,000 | cubic yards | 15,000 | 2.00 | 30,000 |
| **Subtotal** | | | | **509,708** | | | | **293,328** | | | | **371,430** |
| **MISCELLANEOUS** | **$/year** | | | **150,000** | | | | **150,000** | | | | **150,000** |
| **TOTAL W/OUT CONTINGENCIES** | **$/year** | | | **10,179,670** | | | | **3,751,963** | | | | **5,879,905** |
| **CONTINGENCY VALUE** | **$/year** | | | **1,526,951** | | | | **562,794** | | | | **881,986** |
| **TOTAL W/CONTINGENCIES** | **$/year** | | | **11,706,621** | | | | **4,314,757** | | | | **6,761,890** |

## Labor rates

| Labor rates | $/Year avg |
|---|---|
| Plant Manager | 101524.8 |
| Deputy | 52644.8 |
| Operators | 44532.8 |
| Fuel Handling | 44532.8 |
| Maintenance | 42723.2 |
| Administration | 32032 |

http://www.coworkforce.com/lmi/wages/Denver.asp

## Appendix B. Application Forms for Xcel Energy Licensing Agreement, Easement


# ENCROACHMENT APPLICATION INSTRUCTIONS

All applicants for encroachment on Public Service Company of Colorado (PSCo) lands or rights-of-way must complete the attached form and return it along with the required sketch and any other maps and plans of the proposed encroachment to:

**Public Service Company of Colorado**
**Attn: Harry Swinhart**
**Siting and Land Rights**
**550 15th Street, Suite 700**
**Denver, Colorado 80202-4256**

Public Service Company of Colorado charges a $500.00 fee for processing encroachment applications. This fee is in addition to any fees charged for the use of PSCo lands or rights-of-way.

Applications are processed as they are received. Most proposed encroachments require review and approval by PSCo engineering and/or operations staff. Typically, review and approval of a proposed encroachment takes 2-4 weeks, depending on the type of encroachment and the completeness of the application.

If the proposed encroachment is approved, you will receive two copies of the license agreement for execution. Once these agreements are signed, they should be returned for further execution and processing. No encroachment will be permitted until all fees are paid and the agreement is signed on behalf of PSCo.

**APPLICATION FOR ENCROACHMENT**
**ON**
**PUBLIC SERVICE COMPANY RIGHT-OF-WAY**

1. Applicant Information:

Applicant:
_____

Main Contact:
_____

Address:
_____

Phone:_____Fax:_____

Email Address _____

2. If Applicant is a business: Applicant's authorized agent:

3. Location of proposed encroachment:

Street address: _____

Section _____, Township _____, Range _____, County_____

Nearest street or road intersection: _____

4. Public Service Company of Colorado facility:

Electric transmission _____ Gas pipeline _____ Electric distribution _____

Overhead _____ Underground _____ Other _____

5. Describe in detail the proposed encroachment: (height, size, materials, use, etc.):

6. Provide a sketch in AutoCAD Format. If AutoCAD is not available then a legible hand drawn sketch will suffice that shows:

a. The location of the proposed encroachment on the right-of-way.

b. The edges of the right-of-way or easement.

c. The nearest poles, towers or other Public Service Company facilities.

d. Tied into a section corner. (Bearing and distance)

e. Where appropriate roads, streets, streams, creeks, etc.

Attach additional maps or plans as necessary, to fully explain the proposed encroachment.

7. Schedule for the construction/operation of the proposed:

8. Has Utility Notification Center of Colorado (UNCC) 1-800-922.1987 been called to locate facilities?

Yes _____No _____
Date Called _____

9. Applicant's Signature:

_____

Date: _____

Licensee: _____ File With Document #: _____

Investigation #: _____ Agent: _____

Line No. _____ Engineer: _____

Plat No. _____ Section _____ Twp _____ Rge _____

# LICENSE AGREEMENT

This LICENSE AGREEMENT ("License") is made this _____ day of _____, 2006 by and between PUBLIC SERVICE COMPANY OF COLORADO, a Colorado Corporation hereinafter called the "Licensor," and _____ hereinafter called the "Licensee."

## RECITALS

A. The Licensor is the **fee owner** of certain real property ("the Property"), and desires to protect and preserve the utility facilities located thereon and the future use of said real property which is more particularly described as follows:

B. Licensee desires to _____ ("licensed facility") in, under, or along portions of the Property as more particularly shown on Exhibit A, attached hereto and made a part hereof, and desires to obtain Licensor's permission therefore.

## AGREEMENT

NOW, THEREFORE, in consideration of the foregoing, and for other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the parties agree as follows:

(1) The Licensor hereby grants to the Licensee, its successors, and permitted assigns, with respect to such title and interest as the Licensor may have in the Property, and upon the terms and conditions hereinafter stated, the permission and right to construct, maintain, operate, repair, inspect, remove, and replace the licensed facility in, on, under, or along the Property. Such construction shall be located as shown on the Licensee's Exhibit(s) attached hereto and made a part hereof by this reference. If the Licensee's construction requires any deviation in any manner from the Exhibit(s), the Licensee shall notify and obtain approval for any changes from the Licensor in advance of any construction. The Licensee shall prepare and submit to the Licensor as-built Exhibit(s) depicting all deviations from the original Exhibit(s) no later than thirty (30) days after completion of construction.

(2) This License does not convey an interest in real property.

(3) The Licensor intends to use the Property for all purposes in connection with electric power generation, transmission, or distribution and/or natural gas gathering, storage, transmission, or distribution, and the rights herein granted to the Licensee for the use of the Property are subject to the rights of the Licensor to use the Property for such purposes, which rights the Licensor hereby expressly reserves.

(4) The Licensee shall remove at its own expense, the licensed facility from the Property or any part thereof, or relocate the same to a different location on the Property as requested by the Licensor, if the licensed facility should interfere, in the Licensor's sole and absolute discretion, with the operation and maintenance of the Licensor's facilities as now or hereafter constructed. In the event that the Licensee's use of the Property should, in the reasonable judgment of the Licensor, constitute a hazard to the Licensor's facilities or the general public, the Licensor may require immediate removal, relocation, or modification of the Licensee's facilities to eliminate such interference or hazard, and may suspend the Licensee's right to use the Property under this License until such removal, relocation, or modification is completed.

(5) This License is issued subject to any prior licenses, easements, or leases granted by the Licensor for improvements of other parties. The Licensor reserves the right to license others to install improvements in, on, under, or along the Property provided that same shall not interfere unreasonably with facilities herein authorized.

(6) The Licensee shall not do or permit to be done any blasting above, underneath, or near facilities on the Property without first having received prior written permission from the Licensor. Any blasting shall be done in the presence of a representative of the Licensor and in accordance with directions such representative may give for the protection or safety of the facilities located on the Property.

(7) The Licensee agrees that it shall not begin construction on the Property until the Licensee first provides the Licensor with plans and specifications, and until such plans and specifications have been approved by the Licensor. The Licensee shall contact the Utility Notification Center of Colorado (1-800-922-1987) at least two working days prior to the commencement of construction on the Property to arrange for field locating of utility facilities. Further, if the Licensor has constructed electric transmission facilities on the Property, the Licensee shall contact the Licensor's Electric Transmission Lines department at (303) 273-4669 at least four working days prior to the commencement of construction on the Property, and unless waived by said department, no construction shall be performed unless a representative of the Licensor is present at the time and place of construction. The instructions of such representative relating to the safety of the Licensor's facilities will be followed by the Licensee, its agents, and employees. Any damage to facilities on the Property as a result of the above construction shall be paid for or repaired at the expense of the Licensee. These provisions shall also apply to any other work involving construction, maintenance, operation, repair, inspection, removal, replacement, or relocation of the licensed facility on the Property.

(8) The Licensee agrees and understands that if the Licensor has constructed natural gas gathering, storage, transmission, distribution, or related facilities on the Property, the Licensee has been fully advised by the Licensor that such natural gas facilities may now transport and may continue to transport natural gas at significant pressures. The Licensee shall advise all of its employees, agents, contractors, and other persons who enter upon the Property, pursuant to the provisions of this License, of the existence and nature of such natural gas facilities and the danger and risk involved.

(9) The Licensee has been fully advised by the Licensor that the natural gas facilities of the Licensor, if located on the Property, may be subject to cathodic protection by rectifier and related anode

beds. The Licensor shall not be liable for stray current or interfering signals induced in the licensed facility as a result of the operating of the Licensor's cathodic protection system.

(10) The Licensee agrees and understands that if the Licensor has constructed electric power generation, transmission, distribution, or related facilities on the Property, the Licensee has been fully advised by the Licensor that such electric facilities may now transmit and may continue to transmit electric current at significant voltages, and that the conductors on electric lines may not be insulated. The Licensee shall advise all of its employees, agents, contractors, and other persons who enter upon the Property, pursuant to the provisions of this License, of the existence and nature of such electric facilities and the potential danger and risk involved.

(11) (a) (i) As used in this License, the term "Claims" means (1) losses, liabilities, and expenses of any sort, including attorneys' fees; (2) fines and penalties; (3) environmental costs, including, but not limited to, investigation, removal, remedial, and restoration costs, and consultant and other fees and expenses; and (4) any and all other costs or expenses.

(ii) As used in this License, the term "Injury" means (1) death, personal injury, or property damage; (2) loss of profits or other economic injury; (3) disease or actual or threatened health effect; and (4) any consequential or other damages.

(b) To the extent permitted by law, the Licensee covenants and agrees to at all times protect, indemnify, hold harmless, and defend the Licensor, its directors, officers, agents, employees, successors, assigns, parents, subsidiaries, and affiliates from and against any and all Claims arising from, alleged to arise from, or related to any Injury allegedly or actually occurring, imposed as a result of, arising from, or related to (1) this License; (2) the construction, existence, maintenance, operation, repair, inspection, removal, replacement, or relocation of the electric power generation, transmission, or distribution; natural gas gathering, storage, transmission, or distribution; or any other utility facilities located on the Property; or (3) the Licensee's or any other person's presence at the Property as a result of or related to this License.

(c) The Licensee's duty to protect, indemnify, hold harmless, and defend hereunder shall apply to any and all Claims and Injury, including, but not limited to:

(i) Claims asserted by any person or entity, including, but not limited to, employees of the Licensee or its contractors, subcontractors, or their employees;

(ii) Claims arising from, or alleged to be arising in any way from, the existence at or near the Property of (1) electric power generation, transmission, distribution, or related facilities; (2) electricity or electromagnetic fields; (3) natural gas gathering, storage, transmission, distribution, or related facilities; (4) asbestos or asbestos containing materials; (5) any Hazardous Materials, regardless of origin; or

(iii) Claims arising from, or alleged to be arising in any way from, the acts or omissions of the Licensee, its sublicensees, invitees, agents, or employees.

(d) By agreeing to indemnification hereunder, the Licensee does not waive any provisions of the Colorado Governmental Immunity Act.

(12) The Licensor shall use care not to damage the licensed facility in the construction, maintenance, operation, repair, inspection, removal, replacement, or relocation of its facilities located on the Property, and shall give reasonable notice to the Licensee of any of its activities in the immediate vicinity of the licensed facility.

(13) The Licensee shall construct the licensed facility so as to maintain the maximum distance between the licensed facility and the Licensor's electric and/or natural gas facilities, or other facilities located on the Property, allowable by the width and terrain of the Property. If the licensed facility crossed over or under the Licensor's electric and/or natural gas facilities, the crossing shall be as directed by the Licensor. Notwithstanding the foregoing, minimum vertical and horizontal separations, as directed by the Licensor, shall be maintained on all crossings and parallel encroachments.

(14) After initial construction of the licensed facility and thereafter, in the event of resettling, the Licensee shall restore the surface of the Property by grading and compacting any irregularities, reseeding, and/or revegetation as required to restore original conditions.

(15) The Licensee shall reimburse the Licensor for all costs involved for replacing and resetting any section corners, quarter corners, ownership monuments, right-of-way markers, and reference points disturbed or destroyed during the construction, maintenance, operation, repair, inspection, removal, replacement, or relocation of said facilities.

(16) A copy of this License shall be on the Property at all times during construction of the licensed facility.

(17) Upon the abandonment of the use of the Property by the Licensee, the License herein granted shall terminate. Upon termination, the Licensee shall remove the licensed facility from the Property, and shall restore the Property to the Property's condition prior to this License taking effect. Removal of the licensed facility shall be performed under the same terms and conditions as the construction of the licensed facility. If the Licensee should fail to remove the licensed facility and restore the Property, the Licensor may remove the same and restore the Property at the expense of the Licensee.

(18) The Licensee further agrees to provide, keep in full force and effect, and require of its contractors or subcontractors, Workers' Compensation insurance pursuant to the laws of Colorado on all employees entering upon the Property.

(19) This License is not transferable or assignable without the express written permission of the Licensor.

(20) The Licensee shall bear the sole obligation of obtaining such other authority or rights as the Licensee may need in addition to the rights provided in this License for the construction of the licensed facility and use of the Property.

(21) Except with the express written permission of the Licensor, the Licensee shall not bring onto the Property, or permit to be brought onto the Property, any hazardous or toxic substance or material (including petroleum) regulated by the State of Colorado, the United States government, or any other government authority with applicable jurisdiction ("Hazardous Materials"). In the event the Licensee brings Hazardous Materials onto the Property (with or without permission of the Licensor), the Licensee shall comply with all applicable laws, ordinances, and regulations of federal, state, and local governmental agencies related to such Hazardous Materials. The Licensee shall remove such Hazardous Materials from the Property immediately upon request of the Licensor. The Licensee shall bear all costs related to environmental investigation, cleanup, removal, or restoration of any water, air, groundwater, natural resources, soil, or land, including, but not limited to, the Property, incurred as a result of the presence of such Hazardous Materials on the Property, or arising out of the acts or omissions of the Licensee, its agents, sublessees, invitees, or employees.

(22) This License may be executed in two original counterparts, each of which shall be deemed an original of this instrument.

(23) Additional Provisions:

IN WITNESS WHEREOF, this instrument has been executed the day and year first above written.

PUBLIC SERVICE COMPANY OF COLORADO

By: _____

Agreed to and accepted by Licensee this _____ day of _____ , 2006.

_____

NAME OF LICENSEE

_____

NAME AND TITLE OF SIGNEE (Type or Print)

_____

SIGNATURE

_____

Street Address

_____

City, State Zip

_____

Area Code and Telephone Number

# Appendix C. Sample Long-form Fuel Supply Contract

CONTRACT

This AGREEMENT made in duplicate the day of , 200X .

BETWEEN:

***(insert Seller name)***

(hereinafter called the "Seller") with a mailing address at

_____

and

***(insert Buyer name)***

(hereinafter called the "Buyer") with a mailing address at

_____

WHEREAS Buyer proposes to construct and operate a wood biomass fuelled boiler at _____ which, if and when constructed, will require wood biomass fuel to operate;

AND WHEREAS the Seller desires to sell to Buyer and Buyer desires to purchase from Seller wood biomass fuel;

NOW, THEREFORE, in consideration of the promises and of the covenants hereinafter contained, it is agreed as follows:

1. PURCHASE AND SALE. Seller agrees to sell to Buyer and Buyer agrees to purchase from Seller all of wood biomass fuel produced by Seller with a minimum of ____ ***green tons/bone dry tons*** per month during the months of ***July through May***, except that Buyer shall not be obligated to purchase a quantity in excess of ____ ***green tons/bone dry tons*** in any calendar month.

2. SPECIFICATIONS. All wood biomass fuel will meet the specifications in Attachment A.

3. MEASUREMENT. Buyer shall determine the net weight in pounds of each load of wood biomass fuel at destination by weighing the loaded vehicle and deducting the tare weight. Buyer shall then determine the percentage of moisture content in each load by customary field and/or laboratory procedures based on representative samples. This percentage shall be multiplied by the net weight of the load and the product shall be deducted from the net weight of the load. The remainder shall be divided by 2,000 and the quotient shall constitute the number of bone dry tons of wood biomass fuel in the load.

4. TRANSPORTATION, DELIVERY/ACCEPTANCE.

   4.1. Schedule. Buyer shall notify Seller ___ months in advance of the date that Buyer will initially accept wood biomass fuel deliveries. ***(NOTE: This assumes Seller pays delivery charges – which is not always the case)*** Wood biomass fuel shall be transported by Seller and all delivery and transportation costs thereof shall be borne by Seller. All wood biomass fuel purchased hereunder shall be transported by ***truck with live bottom trailer/chip trailer with hinged rear door /bottom-dump trailer***. Acceptance of wood fuel by Buyer shall be from ***7 A.M. to 7 P.M.*** Seller vehicles shall operate in such a way to be consistent with all government regulations related to noise, air emissions and idling vehicles and shall not violate community standards of behaviour.

   Buyer shall provide Seller with a schedule of daily deliveries on a biweekly basis, or every two weeks on the first (1st) and fifteenth (15th) of each month. Buyer, with reasonable notice to Seller, may request an altered delivery schedule to accommodate its work schedules. Seller shall agree to reasonable requested alterations in the regular delivery schedule so long as such alterations do not substantially conflict with Seller's need to remove wood biomass fuel from Seller's operations. Seller shall provide buyer with an updated delivery schedule as soon as practicable after any significant change to the schedule is agreed upon by both Parties.

4.2. Point of delivery. The Seller shall deliver and the Buyer shall receive wood biomass at Buyer's wood biomass energy facility at _____ seven days a week during the hours specified in subparagraph 4.1 or hours specified in any altered delivery schedule agreed upon by both Parties. The Buyer may, on three (3) working days notice redirect all or a portion of the wood biomass fuel shipments to other points of delivery by mutual agreement with Seller, provided that Buyer compensates Seller for any increased delivery and transportation costs. Such additional transportation rates will be at the lowest available transportation rates available to the Buyer or Seller. Title to and risk of loss of wood biomass fuel shall pass to Buyer at Buyer's designated receipt point.

5. DELIVERY REDUCTION. If, in Buyer's judgement, Buyer is unable to economically store or use all wood biomass fuel tendered to it by it's suppliers, Buyer may give Seller ten (10) days notice of a percentage reduction in Seller's normal monthly delivery. "Normal monthly delivery" shall mean the average monthly delivery of wood biomass fuel delivered hereunder by Seller to Buyer during the six (6) calendar months immediately preceding a delivery reduction under this paragraph. In the event, however, that the average monthly quantity delivered during such six (6) month period exceeds the maximum monthly quantity Buyer is obligated to accept under paragraph 1, the latter amount shall be deemed Seller's normal monthly delivery. Buyer shall not be obligated to accept more than the quantity specified in such notice to Seller. Normal monthly deliveries to Buyer's plant from all third party suppliers of hog fuel to whom Buyer is similarly obligated at that time shall be reduced by the same percentage. Seller shall be free to sell to any third party or otherwise dispose of wood biomass fuel not accepted by Buyer, provided, however, that Seller shall not be entitled to enter into any sales or other agreement that would prejudice Seller's obligation to Buyer hereunder during such period of reduction or upon the resumption of normal deliveries to Buyer.

6. PRICE AND PAYMENT.

6.1. The period from the date of commencement of operation of the Buyer's wood fuel boiler until ***five (5)*** years thereafter is hereinafter called the "Initial Period" and the following ***five (5)*** year period is hereinafter called the "Subsequent Period". The price to be paid during the Initial Period per ***bone dry ton/wet ton*** of wood biomass fuel delivered shall be $____. This price shall remain in effect during the life of this Agreement unless adjusted pursuant to subparagraphs 6.2 or paragraph 7. Wood biomass fuel shall be inspected upon delivery. If any load does not meet the fuel specifications in Attachment A, the price to be paid per ***bone dry ton/wet ton*** will be reduced by 25% for that load.

6.2. Seller not more than six (6) months and not less than three (3) months prior to the end of the Initial Period may request an increase in the price for wood biomass fuel to be delivered during the Subsequent Period. Such a request may be made only if Seller has received from a responsible third party (hereinafter called the "Offeror") a bona fide written offer to purchase Seller's entire output of wood biomass fuel for a period not less than five (5) years at a price higher than the current price being paid by Buyer. The requested increase shall be in writing and shall include the name and address of the Offeror, the proposed price and the period during which the Offeror is willing to purchase the wood biomass fuel. Buyer within thirty (30) days after receipt of such a request for an increase shall advise Seller whether it agrees thereto. If Buyer agrees to the increase, the price shall be so adjusted during the Subsequent Period and the increased price shall remain in effect during the remainder of this Agreement. If Buyer declines to agree to the price increase, Seller may, at its option, terminate this Agreement as of the end of the Initial Period.

6.3. Payment for wood biomass fuel shall be made by the fifteenth ($15^{th}$) day of each calendar month for all wood biomass fuel unloaded and measured at destination during Buyer's previous fiscal month. Each payment shall be accompanied by an itemized receipt of the sum of _____ ($ ) as an advance payment for the initial wood biomass fuel to be delivered hereunder.

7. TERM. The term of this agreement shall commence upon the first delivery of hog fuel to Buyer and shall continue, subject to subparagraph 6.2 for a period of ***ten (10)*** years from the date of commencement of operation of Buyer's wood fuel boiler, and shall continue from year to year thereafter unless terminated by either party by written notice to the other given at least six (6) months prior to the end of the original term or any renewal year. Buyer shall advise Seller in writing of the date of commencement of operation of Buyer's hog

fuel boiler.

8. FORCE MAJEURE. Seller shall be excused for failure to deliver wood biomass to Buyer and Buyer shall be excused for failure to accept delivery of hog fuel from Seller in the event, to the extent, and during the times of such failures as caused by flood, acts of God, war or other hostilities, civil commotion, breakdown of machinery, governmental acts, orders or regulations, or by any other cause whether or not of a similar nature beyond Seller's or Buyer's reasonable control.

9. SALE OR LEASE OF FACILITIES BY SELLER. In the event that Seller should sell, lease, convey or otherwise place the facilities for manufacture or production of wood biomass hereunder in the care, custody or control of any person, firm or corporation, or combination thereof not a party to this Agreement, hereinafter called "Business Successor", and should said facilities continue to be employed or utilized, or be capable of being employed or utilized for the manufacture of wood biomass fuel, Seller promises and agrees , for himself and for his Business Successor, that this agreement will continue to be fully and strictly performed according to the terms hereof and that Seller and his Business Successor will make, execute and deliver all documents which may be necessary to assure such performance. In the event the Seller should sell, lease, convey or otherwise place said facilities in the care, custody or control of a Business Successor and, in doing so, should fail or neglect to provide for the interest of the Buyer under this Agreement by requiring, in writing, that Seller's Business Successor fully and faithfully perform all of Seller's duties and obligations under this Agreement for the remainder of the term thereof, then, it is hereby understood and agreed that Buyer may recover from Seller any and all damages which Buyer sustains as a result thereof, including, but not by way of limitation, all costs of every kind and nature and all attorneys' fees which Buyer may be required to incur in securing such damages.

10. FAILURE OF BUYER TO OBTAIN ADEQUATE SUPPLY OF MATERIAL. Not-withstanding any other provision thereof, it is hereby agreed that this Agreement is predicated upon Buyer's ability to obtain an adequate supply of wood biomass fuel at a price that will justify operation of Buyer's proposed wood biomass fuelled boiler. In the event that Buyer does not give delivery notice to Seller pursuant to Paragraph 4 on or before _____ this agreement shall be null and void and of no further force and effect and Buyer shall forfeit the advance payment made for wood biomass fuel.

11. INDEMNITY. Seller shall indemnify and save harmless Buyer and its servants and agents against all costs, suits or claims on account of injuries (including death) to persons or damage to property, caused by agents or personnel of Seller during the performance of this Agreement or resulting from the use by Seller or its affiliates, its customers or licensees of any deliverable or intellectual property developed by Buyer or Seller under this Agreement. Buyer shall indemnify and save harmless Seller against all costs, suits or claims on account of injuries (including death) to persons participating or damage to Buyer property, caused by the wilful or negligent act or omission of personnel of Buyer during the performance of this Agreement.

12. INSURANCE. Commencing not later than the commencement date of this Agreement, Seller and Buyer, each at its own expense, shall secure and maintain Commercial General Liability Insurance in the minimum amount of $1,000,000 combined single limit Bodily Injury and Property Damage each occurrence. Extensions of coverage shall include Contractual Liability, Broad Form Property Damage, Personal Injury, Products and Completed Operations, Cross Liability, and Pollution arising out of heat, smoke or fumes from a hostile fire or upset or overturn of mobile equipment. Each Party shall also secure and maintain an Automotive Liability insurance policy with minimum limits of $1,000,000 per accident combined single limit Bodily Injury and Property Damage. Coverage shall extend to all owned, hired and non-owned vehicles and provide for pollution due to collision, upset or overturn of a vehicle. All policies shall be on an "occurrence" rather than "claims made" basis. Each party shall also secure and maintain statutory Workers' Compensation and Employers Liability Insurance with a limit of $1,000,000. Each Party shall provide the other Party with a certificate of insurance evidencing the insurance required herein. All subcontractors to either Party shall be required by said party to meet the insurance requirements set forth herein.

13. DEFAULT. Except where expressly stated otherwise herein, if either Party shall fail or neglect to perform or observe any of the agreements contained herein on its part to be performed or observed, and such default shall continue for thirty (30) days or more after written notice of such failure or neglect shall be given by the other

Party, or if bankruptcy or receivership proceedings, voluntary or involuntary, shall be commenced against a Party, or if assignment of a Party's property shall be made for the benefit of creditors, then in any such events, the other Party may, by written notice, terminate this Agreement and all rights of such Party hereunder. It is agreed that the remedies given herein are not exclusive and are without prejudice to any other remedy available, and that in addition thereto, the Parties hereto shall have all other remedies available at law or in equity. Any waiver by either Party of a breach of a provision of this Agreement shall be limited to such particular instance and shall not operate as a waiver of or be deemed to waive any future breaches of any of such provisions.

14. NO LIENS. Seller agrees to tender wood biomass fuel to Buyer free and clear of all taxes, liens and encumbrances whatsoever.

15. SEVERABILITY. The invalidity of one or more sections of this Agreement shall not affect the validity of the remaining portions of this Agreement.

16. NOTICE. Notices under this Agreement shall be sent to the parties as follows:

| Seller: | Buyer: |
|---|---|
| ***(Insert name)*** | ***(Insert name)*** |
| ***(Insert title)*** | ***(Insert title)*** |
| ***(Address line 1)*** | ***(Address line 1)*** |
| ***(Address line 2)*** | ***(Address line 2)*** |

17. NON-WAIVER. Failure by either party at any time to require strict performance by the other of any provision hereof shall not constitute a waiver of any breach of the provisions hereof, or of any succeeding breach of this non-waiver clause.

18. This Agreement embodies the entire agreement of the parties hereto and no change or modification shall be valid unless it is in writing and signed by both parties

The parties have executed this Agreement in duplicate as of the date first hereinabove written.

| For Seller | For Buyer |
|---|---|
| _____ | _____ |
| ***(Insert name)*** | ***(Insert name)*** |
| ***(Insert title)*** | ***(Insert title)*** |

**Attachment A. Wood Fuel Specifications**

Wood biomass fuel shall be chipped or ground, free of metal and other foreign material and meet the following maximum criteria:

| | |
|---|---|
| Maximum allowable moisture content | 50% |
| Maximum allowable ash content on a dry weight basis | 3% |
| Maximum weight fraction retained on 2 inch chip screen | 10% |
| Maximum weight fraction passing a 1/8 inch chip screen | 10% |

# Appendix D. Sample Short-Form Supply Contract

## Wood Waste Sales Agreement

It is hereby agreed between _____; herein known as "Buyer" and _____; herein known as "Seller" , that Seller will sell to Buyer quantities of waste wood subject to to the terms and conditions set forth below.

| | |
|---|---|
| Material: | Ground or chipped untreated wood free of metal, stones, debris and other contaminants |
| Price: | $_____/green ton delivered to point of delivery described below |
| Delivery quantity: | Full 40 foot van loads |
| Annual maximum quantity Buyer agrees to take | _____ green tons |
| Point of delivery | _____ |
| | _____ |

Further, it is agreed that, other than a minimum amount required for its own internal needs, the Seller will sell its entire quantity of waste woods specified above that are generated each year to Buyer during the months of ***July through May*** and continuing for a period of three (3) years, unless:

1. Seller installs own waste wood energy system or other waste wood utilization technology, in which case the contract can be terminated on one (1) year's notice.
2. Insolvency, Bankruptcy or Act of God causing either party to no longer continue the relationship.

Finally, the price will be adjusted on each anniversary of this agreement for the year to come, by applying to the price set forth above, a percentage increase equal to the percentage increase Buyer would have paid for ***#6 residual oil/natural gas*** during the year, period ending three (3) months before the anniversary date. At the end of the three (3) year period Buyer has the right to match any bona fided offer for the material specified.

by _____ _____
Company Date

by _____ _____
Company Date

Source: Tennessee Valley Authority Renewables and Special Projects, Biomass Design Manual Industrial Size Systems, Reprint 1991.